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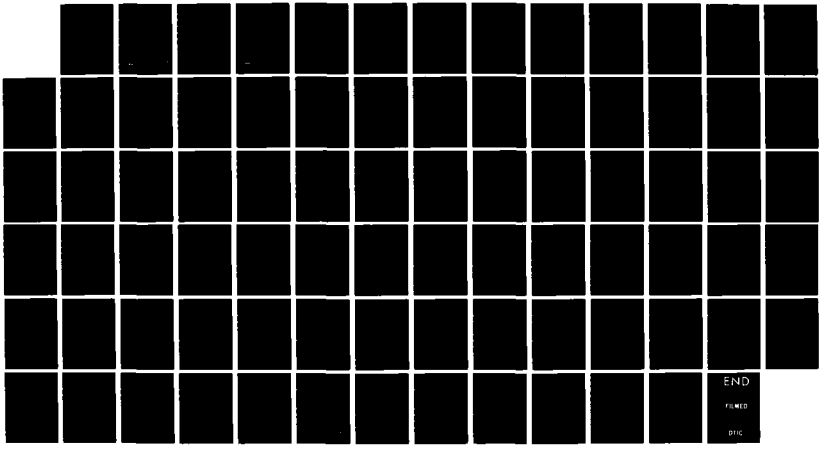

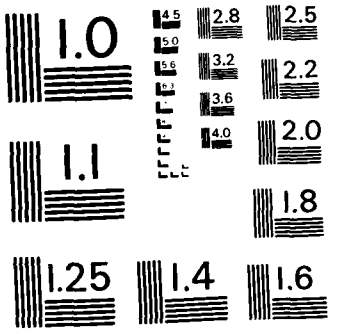

A RAND NOTE

THE ACCURACY OF SIMPLE ENLISTED FORCE FORECASTS

David W. Grissmer

June 1985

N-2078-MIL

Prepared for

The Office of the Assistant Secretary of Defense/ Manpower, Installations and Logistics

Rand
1700 MAIN STREET
P.O. BOX 2138
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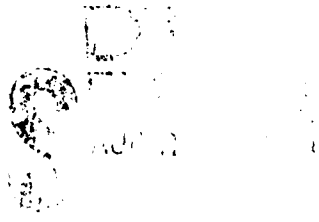

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This Note presents an analysis of the historical accuracy with which enlisted force manpower strengths can be forecast using simple and widely used modeling assumptions. The accuracy of one-, three-, and five-year forecasts is presented for enlisted personnel groups from all four military services for fiscal years 1971 through 1980. Estimating the accuracy of forecasts and analyzing the pattern of errors allow an assessment of the need for more sophisticated techniques, help in developing a strategy for disaggregating enlisted groups when forecasting, and form a basis for the design of an improved enlisted forecasting system. The author finds that the models tested provide reasonably accurate short-term forecasts of the level and structure of enlisted personnel strength. However, long-term forecasts show very large errors for certain enlisted groups. The error pattern, which is stable across the services, shows a distinct structure when estimated by year of service.

PREFACE

This Note presents an analysis of the historical accuracy with which enlisted force manpower strengths can be forecast using simple--and widely used--modeling assumptions. The accuracy of one-, three-, and five-year forecasts is presented for enlisted personnel groups from all four military services for fiscal years 1971 through 1980. This work is a first step in designing and implementing an enlisted forecasting system for the Office of Enlisted Personnel Management. The study was conducted for that office under Task Order 82-II-2 and 83-II-2 in Contract MDA903-80-C-0652. It was sponsored by the Office of the Assistant Secretary of Defense (Manpower, Installations and Logistics) and performed at Rand's Defense Manpower Research Center.

Each year, military pay increases and bonus payments budgets are determined partly on the basis of forecasts of the number of enlisted personnel who will continue serving. Forecasts showing persistent shortfalls from requirements usually result in additional pay--in the form of either bonus payments or pay raises. The accuracy of these forecasts, so critical to sizing large bonus and pay budgets, has not systematically been tracked.

Forecasts, of course, can be made with a variety of models using different assumptions. This Note focuses on the accuracy of a simple, widely used technique to forecast enlisted strengths. Estimating the accuracy of forecasts and analyzing the pattern of errors allow an assessment of the need for more sophisticated techniques, help in developing a strategy for disaggregating enlisted groups when forecasting, and form a basis for the design of an improved enlisted forecasting system.

SUMMARY

Each of the four military services has an interconnected set of enlisted force planning models which are used to estimate critical aggregate manpower parameters such as end strength, accession requirements, first term/career mix, and budget levels for enlisted pay and bonuses. A critical component of each of these models is a forecast of the number and type of enlisted personnel leaving the service. Poor estimates of enlisted force losses can result in higher than necessary enlisted pay and bonus levels or manpower shortages. It can result in policymaking characterized by reaction rather than anticipation, and can have severe long-term opportunity costs in terms of enlisted force structures which deviate substantially from the required structure.

This study documents the historical accuracy of one-, three-, and five-year forecasts for enlisted manpower cohorts for fiscal years 1971 through 1980 for a simple--and widely used--enlisted force forecasting technique. It documents this accuracy for each of the four services for various disaggregated enlisted force groups. As such, it provides managers with realistic estimates of errors for this technique and an improved ability to hedge policies so that enlisted force objectives can be met with a higher degree of confidence. This study also interprets the pattern of errors in forecasting and compares the errors with those of a standard statistical distribution which suggests directions for improving these forecasts. Finally, it describes possible barriers to implementing improved forecasting techniques. This work was undertaken as a first step in the design and implementation of an enlisted forecasting system for the Office of Enlisted Personnel Management.

The simple continuation rate models tested here provide reasonably accurate short-term forecasts of the level and structure of enlisted personnel strength. However, long-term forecasts show very large errors for certain enlisted groups. The error pattern--which is stable across the services--shows a distinct structure when estimated by year of service. For enlisted personnel in the first two years of service, there is a surprisingly small one-year forecast error. For the years

1976-80, the mean absolute percentage error for one-year forecasts has been less than 4 percent for each service. These errors increase to 15-30 percent for three- and five-year forecasts. The largest error rates are for enlisted groups with between three and six years of service and for groups with greater than 20 years of service. For the former group, mean absolute percentage errors for one-year forecasts are less than 10 percent, and increase to the 10-20 percent range for three- and five-year forecasts. For the latter group, one-year forecast errors are less than 10 percent, but can rise to 40 percent for five-year forecasts. Error rates for year of service groups between 7 and 19 are less than 3 percent for one-year forecasts and 9 percent for three- and five-year forecasts. For year of service groups between 12 and 19, the errors are close to random.

One method used to improve simple forecasts is to disaggregate the enlisted force into finely grained groups prior to forecasting. We have found that disaggregation improves forecasting only slightly, and probably most models could be simplified by less disaggregation. We have also found that simple models do extremely well for many groups, and more sophisticated techniques are warranted only for certain groups with high nonrandom error rates.

The pattern of forecast errors is consistent with the hypothesis that nonrandom factors present during years of service 3 through 10 and 20 through 30 are the primary cause of forecast errors. This pattern seems to support the results of econometric models which have shown the importance of factors connected with the economic cycle in retention decisionmaking. Incorporation of these behavioral models into enlisted force planning models may improve forecasting accuracy markedly. This incorporation will allow the services to address an important continuing problem in enlisted personnel management--developing a set of countercyclical policies to mitigate the effects of economic cycles on enlisted force trends. However, this incorporation must take account of barriers which have prevented this incorporation to date, must recognize that ad hoc methods of incorporation might not improve accuracy, and recognize an associated need to develop a process that both develops common economic assumptions across services and tracks the accuracy of service forecasts.

ACKNOWLEDGMENTS

This analysis relied on the construction of an elaborate set of data files at the Defense Manpower Data Center (DMDC). We wish to thank Michael Dove and Monty Kingsley for constructing these files. We also wish to thank Robert Brandewie, Deputy Director, DMDC, for advice in constructing the file. This Note also benefitted from a constructive review by Grace Carter of Rand. We also wish to thank Barbara Eubank for typing the numerous drafts and Jeanne Heller for editing the manuscript.

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Table 2.6

ACTIVE DUTY MARINE CORPS ENLISTED FORCE (FY71-80)

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	43,582	49,382	46,580	42,108	48,899	42,735	39,359	35,056	36,036	37,262
2	51,109	39,078	45,286	41,963	37,415	39,241	38,264	35,454	31,188	32,981
3	28,643	27,572	24,461	26,468	29,253	26,396	31,638	33,708	31,886	28,650
4	22,350	17,911	17,216	16,633	18,255	18,784	19,399	24,185	23,159	23,809
5	5,527	7,348	6,504	6,958	7,164	7,479	7,541	7,324	8,264	9,439
6	4,641	3,891	5,261	5,220	5,595	5,764	6,006	5,903	5,765	6,543
7	2,487	3,679	3,156	4,402	4,369	4,763	4,615	4,850	4,691	4,875
8	2,363	1,957	3,002	2,740	3,748	3,712	3,957	3,688	3,810	3,936
9	1,720	2,005	1,837	2,609	2,358	3,356	3,204	3,165	2,875	3,248
10	2,108	1,488	1,693	1,534	2,085	2,058	2,709	2,563	2,534	2,563
11	1,748	1,761	1,191	1,377	1,265	1,764	1,705	2,171	2,190	2,276
12	2,373	1,590	1,647	1,108	1,273	1,192	1,597	1,528	1,962	2,044
13	1,923	2,304	1,492	1,525	1,028	1,176	1,092	1,464	1,427	1,814
14	1,441	1,980	2,165	1,390	1,423	966	1,112	1,025	1,391	1,358
15	1,772	1,507	1,931	2,050	1,299	1,120	918	1,060	984	1,330
16	2,121	1,772	1,548	1,851	1,963	1,300	1,088	875	1,028	971
17	1,856	2,206	1,680	1,511	1,784	1,811	1,262	1,051	865	1,009
18	3,456	1,912	2,192	1,649	1,497	1,593	1,776	1,245	1,040	853
19	2,484	3,723	1,744	2,165	1,623	1,709	1,567	1,745	1,228	1,025
20	2,258	1,915	2,911	1,464	1,886	1,350	1,478	1,392	1,705	1,195
21	916	967	769	1,295	775	864	696	845	781	935
22	601	516	527	478	871	498	602	474	562	511
23	501	302	346	383	363	437	368	442	348	403
24	537	302	191	264	310	339	344	274	337	267
25	417	368	230	158	217	233	274	273	208	284
26	343	309	275	193	132	157	202	237	229	185
27	245	194	184	223	152	112	122	159	188	172
28	204	108	143	143	171	88	90	96	130	143
29	170	114	73	104	103	133	68	72	78	108
30	121	112	88	61	63	48	99	56	56	64
30+	30	35	40	39	28	37	27	31	24	34
UNK	557	289	172	4	0	1	0	0	0	0
TOTAL	190,604	178,597	176,535	170,070	177,367	171,216	173,179	172,411	166,971	170,287

Table 2.5

ACTIVE DUTY NAVAL ENLISTED FORCE (FY71-80)

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	90,457	94,262	100,715	86,131	91,457	86,182	87,851	73,728	72,159	78,322
2	93,979	79,080	82,252	86,515	71,630	76,758	73,576	78,029	65,719	65,902
3	94,595	64,227	54,362	62,939	66,419	58,887	62,431	66,102	70,379	60,622
4	70,257	80,651	55,886	46,529	46,686	43,937	45,529	53,783	55,447	60,515
5	15,815	20,551	23,593	21,080	21,932	24,935	22,809	24,416	28,593	28,115
6	14,847	13,376	17,608	19,593	18,876	21,680	22,703	20,362	20,027	22,496
7	12,756	12,151	10,446	13,204	15,288	15,558	16,867	17,447	16,051	15,670
8	11,330	11,470	10,965	9,293	12,035	14,142	14,248	15,330	15,520	14,593
9	9,764	10,082	10,357	9,902	8,514	11,496	12,423	11,721	12,713	13,193
10	11,029	8,894	9,352	9,493	9,147	8,116	10,164	10,814	10,225	11,329
11	11,038	10,180	8,313	8,566	8,843	7,618	7,333	9,086	9,538	9,128
12	10,735	10,622	9,816	7,930	8,239	8,933	7,261	6,954	8,579	8,991
13	11,400	10,372	10,406	9,440	7,619	7,763	8,538	6,854	6,632	8,113
14	11,876	11,063	10,167	10,101	9,215	7,413	7,471	8,222	6,622	6,371
15	10,729	11,599	10,732	9,945	9,948	8,628	7,166	7,214	7,913	6,388
16	13,992	10,535	11,208	10,476	9,758	9,372	8,426	6,978	6,982	7,711
17	14,483	13,722	10,299	10,909	10,199	9,991	9,156	8,228	6,752	6,796
18	8,070	14,305	13,596	10,122	10,724	9,869	9,801	8,989	8,073	6,628
19	7,953	7,841	13,881	12,827	9,515	10,456	9,347	9,360	8,777	7,927
20	6,751	5,210	5,764	8,956	8,029	5,822	6,733	6,359	7,768	7,240
21	2,156	3,231	2,688	2,813	4,404	3,879	3,272	3,867	3,558	4,002
22	752	1,371	2,149	1,756	1,730	2,955	2,595	2,208	2,423	2,386
23	1,173	500	974	1,479	1,187	1,402	2,017	1,796	1,504	1,656
24	1,373	863	391	763	1,072	757	1,058	1,482	1,265	1,089
25	765	1,063	714	305	626	833	584	832	1,148	941
26	1,161	649	922	603	246	589	704	472	673	915
27	744	850	531	691	451	216	458	510	343	492
28	593	581	702	428	561	282	164	351	402	260
29	853	523	496	628	366	466	236	148	307	340
30	612	688	444	414	467	268	350	178	117	211
30+	203	157	279	254	222	145	135	153	118	111
UNK	0	0	0	651	117	359	165	303	173	0
TOTAL	542,241	510,669	490,008	474,736	465,522	459,707	461,571	462,276	456,500	458,453

Table 2.4

ACTIVE DUTY ARMY ENLISTED FORCE (FY71-80)

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	283,505	166,724	190,653	159,949	159,700	160,186	144,082	114,935	123,301	144,249
2	275,427	187,576	144,899	162,716	133,710	125,074	133,661	125,562	101,182	108,382
3	130,066	61,219	89,355	94,854	107,961	102,269	104,251	120,088	111,401	90,696
4	50,239	33,689	27,297	35,773	46,642	47,311	47,324	52,724	62,488	62,802
5	25,262	32,462	24,916	22,250	31,799	42,756	36,392	36,630	35,569	42,017
6	19,505	21,440	26,856	21,446	20,318	30,355	37,582	32,230	33,096	31,678
7	13,472	17,205	17,903	22,509	19,176	18,229	25,814	31,115	27,237	27,823
8	12,039	12,028	14,963	15,454	20,073	16,724	15,720	21,715	25,173	22,673
9	11,106	10,734	10,337	12,631	13,494	17,605	13,808	13,398	17,883	21,346
10	12,524	10,293	9,686	9,134	11,171	12,243	15,104	12,232	11,988	16,040
11	10,705	12,045	9,792	8,972	8,465	10,435	10,928	13,752	11,255	10,971
12	10,805	10,184	11,487	9,131	8,440	7,910	9,465	10,119	12,865	10,430
13	12,141	10,305	9,770	10,864	8,590	7,753	7,287	8,800	9,493	12,061
14	9,333	11,893	10,157	9,469	10,517	7,865	7,295	6,923	8,343	8,990
15	9,259	9,082	11,755	9,901	9,201	9,495	7,489	7,047	6,696	7,996
16	9,440	9,188	9,116	11,473	9,692	9,354	9,193	7,290	6,838	6,487
17	10,588	9,451	9,147	9,024	11,347	9,431	9,162	9,062	7,140	6,691
18	11,053	10,602	9,501	9,102	8,924	10,562	9,259	9,064	8,952	7,027
19	12,940	10,998	10,625	9,364	8,997	9,739	10,463	9,213	8,998	8,849
20	9,540	12,878	10,895	10,480	9,276	8,723	9,644	10,377	9,095	8,896
21	8,041	5,136	6,440	4,853	5,130	4,096	4,320	5,421	5,816	5,231
22	2,749	5,186	2,995	3,841	3,118	2,855	2,764	2,814	3,528	3,682
23	3,839	1,897	3,666	2,062	2,725	1,968	2,137	2,108	2,063	2,504
24	2,957	2,824	1,321	2,522	1,510	1,962	1,533	1,643	1,557	1,505
25	2,203	2,053	1,915	859	1,806	1,092	1,564	1,219	1,261	1,174
26	2,557	1,676	1,544	1,458	684	1,296	916	1,348	989	1,018
27	1,566	1,795	1,075	982	992	599	948	721	1,015	718
28	1,320	930	1,049	599	627	457	409	655	490	698
29	1,505	844	588	663	443	520	357	318	511	368
30	738	979	515	384	448	263	377	254	234	375
30+	578	478	477	264	167	81	43	67	48	53
UNK	4,862	2,855	1,134	1,363	3,011	799	742	490	473	286
TOTAL	971,864	686,649	681,829	674,346	678,154	680,007	680,033	669,334	656,978	673,716

Table 2.3

ACTIVE DUTY ENLISTED FORCE (FY71-80)

POS/YEAR	71	72	73	74	75	76	77	78	79	80
1	509,528	389,320	423,139	356,333	367,486	355,715	336,759	285,069	292,436	325,394
2	484,027	387,930	344,007	364,590	301,372	301,530	305,300	297,795	252,976	261,362
3	351,785	211,939	242,713	246,052	265,857	237,932	250,367	273,127	265,998	229,605
4	211,426	218,727	153,319	152,801	164,560	158,737	152,665	175,831	188,627	196,002
[illegible]	64,276	84,251	85,280	69,077	85,991	99,090	94,264	94,517	95,273	103,655
[illegible]	56,226	55,725	71,738	74,067	62,266	82,732	86,878	82,605	81,136	80,284
[illegible]	40,469	49,779	47,568	60,427	64,177	53,827	70,294	72,240	67,628	66,124
[illegible]	37,764	36,523	43,511	41,298	53,415	53,199	47,096	60,394	61,186	58,732
[illegible]	32,940	33,459	32,072	37,577	36,341	48,986	45,723	39,396	50,389	51,818
[illegible]	38,505	31,024	31,009	29,291	34,296	34,829	43,672	41,070	34,974	45,238
11	37,081	36,767	29,432	28,890	27,466	31,285	31,919	39,931	37,484	32,052
12	35,223	35,774	35,464	27,993	27,649	26,913	29,299	29,993	37,268	34,975
13	35,183	34,072	34,687	33,903	26,792	25,820	25,502	27,649	28,294	35,162
14	33,039	34,684	33,447	33,756	33,061	25,868	24,852	24,577	26,620	27,183
15	35,601	32,565	34,096	32,719	33,149	30,210	25,119	24,143	23,838	25,785
[illegible]	42,041	35,287	32,195	33,401	32,179	32,607	29,591	24,531	23,567	23,309
[illegible]	55,439	41,761	34,796	31,660	32,902	32,978	32,073	29,145	24,030	23,137
[illegible]	44,516	55,209	41,621	34,468	31,324	31,529	32,532	31,688	28,784	23,736
[illegible]	46,718	44,393	54,511	40,630	33,691	31,689	30,839	31,932	31,330	28,479
[illegible]	51,351	43,191	41,303	49,010	35,382	28,335	27,582	27,521	30,120	29,613
23	23,602	24,681	19,351	18,910	23,845	17,219	14,921	15,672	15,235	16,750
[illegible]	8,031	15,900	15,296	12,534	12,384	14,687	11,547	10,262	10,087	9,921
[illegible]	10,183	5,744	11,319	10,923	9,042	10,529	10,620	8,622	7,298	7,066
[illegible]	9,547	7,730	4,126	8,128	7,637	5,697	7,465	7,532	5,964	5,133
[illegible]	5,975	7,210	5,654	2,945	6,243	5,740	4,606	5,993	5,766	4,549
[illegible]	6,434	4,858	5,687	4,539	2,417	5,526	5,002	3,950	4,904	4,704
[illegible]	3,901	4,688	3,286	3,670	2,750	1,809	3,362	3,055	2,481	3,052
[illegible]	3,348	2,639	3,040	2,058	2,340	1,443	1,220	2,404	2,085	1,696
[illegible]	4,012	2,472	1,802	1,975	1,287	1,609	993	860	1,574	1,363
[illegible]	2,439	2,911	1,728	1,303	1,320	823	1,166	699	623	1,096
[illegible]	1,186	1,199	1,282	820	459	291	233	297	234	273
[illegible]	7,892	3,237	1,643	2,462	5,139	1,370	1,196	1,368	1,193	1,410
TOTAL	2329688	1975649	1920122	1848210	1824219	1790554	1784657	1773868	1739402	1758658

Table 2.3 displays the active enlisted force population by years of service (YOS) as of the end of each fiscal year.[2] Tables 2.4 through 2.7 provide a similar display for each service. This period was characterized by a declining force size in the aftermath of Vietnam and the transition to an all-volunteer force. The Army experienced the largest drop in enlisted strength during the period--a decline of 31 percent from 972,000 to 674,000. The other services experienced smaller declines.

Tables 2.8 through 2.12 summarize the continuation rates for individuals enlisted at the beginning of each fiscal year. These data provide the percentage of individuals ennumerated in Tables 2.3 through 2.7 who are still present one year later. These annual retention rates[3] are one measure of force stability and are key parameters in manpower planning.

Annual continuation rates differ by years of service and over time in easily explainable ways. Overall continuation rates for DoD enlisted personnel (see Table 2.13) rose from 66.1 to 82.3 percent between FY71 and FY80. This dramatic rise in force-wide retention rates is primarily attributable to changes in manpower policy and personnel characteristics triggered by the end of the Vietnam war and the transition to an all-volunteer force. During the Vietnam war, most of the expansion in force size was from draftees who were cycled through the force for short two-year terms, causing low overall retention rates. The post-Vietnam reduction in force size in FY71 and FY72 reduced the number of draftees

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[2]From FY71-FY76 the end of the fiscal year was June 30. For FY77-FY80 the end of the fiscal year was September 30.

[3]In this Note, we will use retention or continuation rate to indicate a ratio, where the denominator is given by the number of individuals present at the beginning of a fiscal year and the numerator as the number of those individuals still present as evidenced by social security matches one year later. Reenlistment rate is the ratio of those accepting a new term commitment to those having an ETS decision during a year. Extension rate is the ratio of those staying but not accepting a term commitment to those having an ETS decision. In modeling and characterizing entire manpower systems, retention rates have the advantage that it is unnecessary to distinguish between reenlistment and extension. While most econometric work has focused on a particular reenlistment decision, more recent work has shown that extension behavior is also an important component of retention.

attention because larger deviation from requirements will occur more frequently.

The expected accuracy of prediction also varies with the retention probability. Other things equal, percentage deviation from requirements will be less frequent with retention groups having higher retention probabilities. For instance, at the 95 percent confidence level and n = 1000, the accuracy falls from 12.3 percent at p = .2 to 3.1 percent at p = .8.

Actual retention behavior may not follow the binomial distribution because the decisions are influenced by nonrandom factors such as civilian wage and unemployment, and policy factors such as military pay and reenlistment eligibility criteria. However, the extent to which these nonrandom factors affect retention can be measured by how far the results of year to year variation differ from the binomial distribution. In our simple model, the binomial distribution gives a minimum possible uncertainty[1] in accuracy of repeated trials. Other nonpolicy influences will always act to increase this deviation over the long run.

THE DATA

At Rand's request, the Defense Manpower Data Center has constructed a file which determines the end of the fiscal year continuation status for each individual in the active force at the beginning of the fiscal year. Starting with the FY71 active force personnel file, a flag has been attached to each individual record indicating whether the individual was present at the end of the fiscal year (June 30, 1972). This file contains records for FY71 through FY80--a total of over 25 million records. (See Appendix A for the data elements on the file.)

This micro-data file basically summarizes the annual retention behavior of each person in the active force over the period FY71-FY80. As such, it can serve as the basis for tracking the accuracy of various methods for forecasting retention.

[1]This assumes that the correlation between events is zero. Certain manpower policies directed toward correlating retention decisions can reduce this uncertainty below binomial. An example would be initiating a bonus policy late in a time period in response to low retention rates early in a time period.

Table 2.2

EXPECTED YEAR TO YEAR PERCENTAGE ACCURACY IN REENLISTMENT PROBABILITY ASSUMING BINOMIAL DISTRIBUTION

		Confidence Level				
		50%	75%	90%	95%	99%
p = .20	N = 100	13.5	23.0	32.9	39.2	51.5
	N = 1000	4.3	7.3	10.4	12.3	16.2
	N = 10,000	1.4	2.3	3.3	3.9	5.2
	N = 100,000	.4	.7	1.0	1.2	1.6
p = .40	N = 100	8.3	14.1	20.2	24.0	31.5
	N = 1000	4.1	7.0	10.1	12.0	15.8
	N = 10,000	.8	1.4	2.0	2.0	3.2
	N = 100,000	.4	.7	1.0	1.2	1.6
p = .50	N = 100	6.8	11.5	16.5	19.6	2.58
	N = 1000	2.1	3.6	5.2	6.2	8.1
	N = 10,000	.7	1.2	1.7	2.0	2.6
	N = 100,000	.2	.4	.5	.6	.8
p = .60	N = 100	5.5	9.4	13.4	16.0	21.0
	N = 1000	1.7	3.0	4.3	5.1	6.7
	N = 10,000	.6	.9	1.3	1.6	2.1
	N = 100,000	.2	.3	.4	.5	.7
p = .8	N = 100	3.4	5.8	8.2	9.8	12.9
	N = 1000	1.1	1.8	2.6	3.1	4.1
	N = 10,000	.3	.6	.8	1.0	1.3
	N = 100,000	.1	.2	.3	.3	.4

management techniques for Military Occupational Specialty (MOS) groups of different size. Other things equal, MOS with a small number of people will likely have a larger percentage deviation from requirements than those having more people. In a sense, large MOS groups tend to manage themselves, whereas smaller MOS groups require more management

Table 2.1

MEAN AND STANDARD DEVIATION OF BINOMIAL DISTRIBUTION

Number Reenlisting	Reenlistment Rate .2	.4	.5	.6	.8
10	2 (1.3)	4 (1.5)	5 (1.6)	6 (1.5)	8 (1.3)
100	20 (4)	40 (4.9)	50 (5)	60 (4.9)	80 (4)
1000	200 (12.6)	400 (15.6)	500 (15.8)	600 (15.6)	800 (12.6)
10,000	2000 (40)	4000 (49)	5000 (50)	6000 (49)	8000 (40)
100,000	20,000 (126)	40,000 (155)	50,000 (158)	60,000 (155)	80,000 (126)

If the binomial distribution accurately describes retention decisions, the confidence levels for predicting next year's retention rate, given this year's rate, can be derived. For instance, if this year's retention rate is p, next year's rate will be between p +/- 2 PSD in 96 out of 100 years. For p = .2 and n = 1000, the limits are .20 +/- .063. For p = .2 and n = 10,000, the limits are .20 +/- .02. Of course, for a given n and p, the size of the bands around the mean depends on the confidence level with which the prediction is desired. A band that includes 99 out of 100 predictions will be wider than one that is accurate in only 90 out of 100 predictions. Table 2.2 provides the percentage bands around the mean for different n and p combinations and confidence limits. For example, referring to the number in the fourth column (95 percent) and second row (p = .2, n = 1000), the interpretation is that in 95 years out of 100, next year's retention rate will differ from this year's by less than 12.3 percent. Thus, in 95 out of 100 years, p will be between .2 +/- (12.3)(.2) = .2 +/- .025.

The expected accuracy of prediction varies strongly with the number of personnel making decisions. At the 95 percent confidence limit, our accuracy of 12.3 percent is expected with 1000 people, while 3.9 percent is expected with 10,000 people. This fact has implications for

In the binomial model, the magnitude of year to year variation in retention rates will depend on the number of people making decisions each year and the average probability of a retention decision. Taking the standard deviation as a measure of the expected year to year variation, Table 2.1 presents the expected number of individuals retained and the year to year variation for different group sizes and average reenlistment probabilities. For instance, if we take p = .20 for an individual first-term retention decision and 100 individuals are making retention decisions, then

$$M = .2(100) = 20$$

$$S = \sqrt{100(.2)(.8)} = 4$$

The mean number of personnel retained is 20 and in a sequence of 25 years where exactly 100 individuals make retention decisions each year, we would expect that M would fall between $M + \sigma = 24$ and $M - \sigma = 16$ for 17 out of the 25 years, or M would fall between $M + 2\sigma$ and $M - 2\sigma$ in 24 out of the 25 years. If actual retention rates in a series of years show greater variation than predicted from this model, it is likely that nonrandom factors are present that change the average reenlistment probability from year to year.

Another measure of variation is the percentage standard deviation (PSD) given by

$$d = \frac{\Sigma}{M} = \sqrt{\frac{q}{np}}$$

For 100 people making retention decisions where p = .2, the annual PSD is 20 percent. The PSD declines as the number of individuals making decisions increases. For p = .2, a group of 1000 people has a PSD of 6.3 percent, while a group of 10,000 has a PSD of 2.0 percent.

II. TESTING FOR THE INFLUENCE OF NONRANDOM VARIABLES ON RETENTION DECISIONS

Each individual retention decision can be modeled as an event with two possible outcomes--either stay or leave the service. If we assume that each decision is made randomly, the binomial model can provide the expected number of individuals retained and the level of year to year variation expected in retention rates. This variation represents the minimum year to year variation achievable when nonrandom factors are absent. In this section, we will compare the historical accuracy of year to year continuation rates with those generated by the binomial model to determine the extent of influence of nonrandom factors. The pattern of error can also help determine the factors causing the nonrandom errors.

A SIMPLE BINOMIAL MODEL OF RETENTION DECISIONS

If we assume each reenlistment decision to be a binomial event, then p can be taken as the annual probability of retention for an individual in a given military service:

$$M = np$$

$$\sigma = \sqrt{npq}$$

where M = the mean of the binomial distribution
σ = the standard deviation
n = the number of individuals making retention decisions
p = the probability of retention for a single individual
$q = (1 - p)$ = the probability of retention not occurring in a single trial

techniques, but on the ability to produce timely and accurate forecasts. Without systematic analysis of the forecasting records of models, no basis exists to choose between alternative models or to provide a coherent rationale for policy choices.

The results indicate that error rates vary widely according to enlisted group. Certain nonrandom factors contribute heavily to forecast errors for enlisted groups with 3 to 10 years of service making reenlistment decisions. The pattern of these errors points to factors associated with the economic cycle. These factors have been incorporated through behavioral models into enlisted force planning systems since the early 1980s, which should markedly improve enlisted force forecasting. Forecasting records for other enlisted groups show fewer errors. For enlisted personnel with 11 to 20 years of service, errors were close to random. Enlisted groups with more than 20 years of service showed moderate nonrandom components. Forecasts for attrition in the early years of service showed nonrandom factors; however, actual percentage deviations were fairly small--usually less than 3 percent.

With the simple continuation models tested here, the expected accuracy of one-year forecasts is extremely good. Maximum error rates occur for groups with 2 to 4 and 20 to 30 years of service, where the average forecast error is less than 10 percent. For other groups, error rates are generally less than 3 percent. However, this accuracy is somewhat misleading, since only about 20 to 25 percent of the force makes an ETS (end of term of service) decision each year. Error rates for three- and five-year forecasts are much worse and tend to show the cumulative effects of poor forecasting at the ETS point. Error rates for five-year forecasts for the hardest to predict groups in the early years of service range between 15 and 30 percent. Patterns in error rates among the services are remarkably similar.

Section II compares errors from a simple forecasting technique used in the FY71-80 time period to those predicted by the binomial model to determine the presence of nonrandom factors. Section III documents the accuracy of the simple technique in predicting the size of various enlisted force groups. Section IV describes ways of improving enlisted force forecasting and the implications of the results for design of an OSD enlisted force planning system. Section V summarizes results of the analysis.

In developing strategies for improving manpower forecasts, the errors can provide a guide to which groups have the largest systematic errors, and therefore have the highest potential for improvements through development of more sophisticated behavioral models. The error estimates also indicate how much improvement might be expected from more sophisticated models. The simple nonbehavioral estimates tested here were the primary technique used in large planning models during the FY71-80 period. Since that time, the services have begun to incorporate some behaviorally based forecasting techniques for certain enlisted groups in their planning models, which should improve their forecasting ability. However, many enlisted groups are still forecast using the simpler models. The analysis in this Note can help in deciding if appropriate choices are being made for using the more sophisticated models.

Knowing the level of random and systematic error can also improve policymaking by allowing uncertainity to be taken more explicitly into account. Knowing the level of uncertainity allows managers to hedge in order to meet manpower requirements with a given degree of confidence. For instance, for certain critical skill requirements where shortages have high costs, planners can efficiently meet requirements with given confidence levels if the likely errors are known.

Beyond the specific uses of error analysis mentioned above, this Note seeks to encourage the analysis of errors as a central part of the enlisted planning system at the OSD level. Duplication of the large models used by each service in their planning process is not warranted; however, careful and systematic monitoring of the manpower forecasts for each service and analysis of errors can provide the proper incentives for the services to improve their models and to identify unexpected and perhaps harmful long-term impacts of service policies. In the long run, it will also identify successful modeling techniques in each service which might be transferred to other services, and help develop an improved base of common forecasting assumptions across the services. An example of the latter would be common macroeconomic assumptions in forecasts. Ultimately, the value of any model that forecasts manpower depends not on the sophistication of the statistical or economic

statistical fluctuation. Systematic errors in manpower forecasts that change these average year to year forecasts can arise from multiple sources, but one common source is behavioral responses of enlisted personnel to changing policies or civilian economic opportunities or changes in the organizational environment. Estimates of the level of systematic errors can be obtained empirically from historical forecasts if comparisons are made between simple estimated random error levels and actual changes in year to year manpower levels.

This Note develops estimates of the errors in manpower forecasts using enlisted force data from fiscal years 1971 through 1980. Statistical assumptions are first used to estimate the magnitude of random errors in various kinds of forecasts. These forecasts include projections of the enlisted inventory for each service by years of service and for various demographic groupings. Next, the empirical accuracy of a simple--and widely used--nonbehavioral forecasting technique which assumes stable year to year retention is calculated for one-, three-, and five-year forecasts for the same enlisted force groups. Comparisons between the level of random errors and actual errors using the nonbehavioral forecasts allow inferences about the level of systematic errors in manpower forecasts.

Knowing the level of random and systematic errors in various kinds of manpower forecasts can aid the design of improved enlisted force manpower models. This study addresses a series of preliminary questions that need to be addressed prior to the design of an enlisted manpower forecasting system for OSD. These questions are:

1. Does the historical accuracy of simple projection methods indicate the need for more sophisticated techniques?
2. Does the pattern of forecast deviations indicate the need to incorporate variables tracking economic cycles?
3. Does the pattern of forecast errors indicate which manpower groups need more sophisticated models?
4. Does the pattern of forecast errors determine an appropriate disaggregation scheme when forecasting for enlisted personnel?

I. INTRODUCTION

Manpower forecasts of the number and quality of enlisted personnel who will remain in the service are critical components in setting and changing enlisted manpower policies. Forecasts that show persistent shortfalls in occupational areas result in increased bonus payments or special pays. Forecasts of aggregate manning levels are used to help determine the annual adjustments to the basic pay tables and figure prominently in suggested changes to the military retirement system.

Besides these obvious direct effects on compensation policy, forecasts also play a prominent role in estimating and allocating annual budgets for compensation, training, and recruiting resources. Each year the services must forecast manpower losses and establish accession requirements sufficient to meet Congressionally imposed fiscal year end strengths. These accession requirements--which depend on forecasts of losses--are used to establish annual resources for training and recruiting. The annual compensation budget is then based on the grade and experience distribution of those remaining as well as the number and timing of new accessions.

The efficiency of the various policies established on the basis of manpower forecasts depends critically on the accuracy of those forecasts. Inaccurate forecasts can result in base pay, benefit, and bonus levels higher or lower than necessary, leading to either a surplus or shortage of personnel. They can further result in inefficient allocations of resources between compensation, training, and recruiting budgets. For instance, predicting a higher level of accession requirements than necessary would mean unnecessarily high training and recruiting budgets.

Errors in forecasts are usually classified as either random or systematic. The level of random errors presumably provides a lower limit to the ultimate accuracy of forecasts, and this level of random errors can be estimated if certain statistical assumptions are made concerning manpower decisions. This simple statistical model would predict stable average forecasts from year to year with random

Table 2.7

ACTIVE DUTY AIR FORCE ENLISTED FORCE (FY71-80)

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	91,984	78,952	85,191	68,145	67,430	66,612	65,467	61,350	60,940	65,561
2	63,512	82,196	71,570	73,396	58,617	60,457	59,799	58,750	54,887	54,097
3	98,481	58,921	74,535	61,791	62,224	50,380	52,047	53,229	52,332	49,637
4	68,580	86,476	52,920	53,866	52,977	48,705	40,413	45,139	47,533	48,876
5	17,672	23,890	30,267	18,789	25,096	23,920	27,522	26,147	22,847	24,084
6	17,233	17,018	22,013	27,808	17,477	24,933	20,587	24,110	22,248	19,567
7	11,754	16,744	16,063	20,312	25,344	15,277	22,998	18,828	19,649	17,756
8	12,032	11,068	14,581	13,811	17,559	18,621	13,171	19,661	16,683	17,530
9	10,350	10,638	9,541	12,435	11,975	16,529	16,288	11,112	16,918	14,031
10	12,844	10,349	10,278	9,130	11,893	12,412	15,695	15,461	10,227	15,306
11	13,590	12,781	10,136	9,975	8,893	11,468	11,953	14,922	14,501	9,677
12	11,310	13,378	12,514	9,824	9,697	8,878	10,976	11,392	13,862	13,510
13	9,719	11,091	13,019	12,074	9,555	9,128	8,585	10,531	10,742	13,174
14	10,389	9,748	10,958	12,796	11,906	9,624	8,974	8,407	10,264	10,464
15	13,841	10,377	9,678	10,823	12,701	10,967	9,546	8,822	8,245	10,071
16	16,488	13,792	10,323	9,601	10,766	12,581	10,884	9,388	8,719	8,140
17	28,512	16,382	13,670	10,216	9,572	11,745	12,493	10,804	9,273	8,641
18	21,937	28,390	16,332	13,595	10,179	9,505	11,696	12,390	10,719	9,228
19	23,341	21,831	28,261	16,274	13,556	9,785	9,462	11,614	12,327	10,678
20	32,802	23,188	21,733	28,110	16,191	12,440	9,727	9,393	11,552	12,282
21	12,489	15,347	9,454	9,949	13,536	8,380	6,633	5,539	5,080	6,582
22	3,929	8,827	9,625	6,459	6,665	8,379	5,586	4,766	3,574	3,342
23	4,670	3,045	6,333	6,999	4,767	6,722	6,098	4,276	3,383	2,503
24	4,680	3,741	2,223	4,579	4,745	2,639	4,530	4,133	2,805	2,272
25	2,590	3,726	2,795	1,623	3,594	3,582	2,184	3,669	3,149	2,150
26	2,373	2,224	2,946	2,285	1,355	3,484	3,180	1,893	3,013	2,586
27	1,346	1,849	1,496	1,774	1,155	882	1,834	1,665	935	1,670
28	1,231	1,020	1,146	888	981	616	557	1,302	1,063	595
29	1,484	991	645	580	375	490	332	322	676	547
30	968	1,132	681	444	342	244	340	211	216	446
30+	375	529	486	263	42	28	28	46	44	75
UNK	2,473	93	337	444	2,011	211	289	575	547	1,124
TOTAL	624,979	599,734	571,750	529,058	503,176	479,624	469,874	469,847	458,953	456,202

Table 2.8

CONTINUATION RATES FOR ACTIVE DUTY ENLISTED PERSONNEL

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	73.659	85.269	84.061	81.752	82.873	83.899	86.345	86.615	86.692	86.292
2	42.484	60.349	69.667	70.422	74.742	81.293	88.324	88.461	89.603	88.089
3	60.301	68.567	60.809	64.006	61.037	62.078	68.459	67.405	71.259	75.089
4	35.907	35.337	41.791	52.075	53.963	56.424	59.388	51.906	51.794	56.473
5	80.733	82.319	84.466	86.524	87.459	86.379	86.233	84.566	82.623	84.735
6	84.267	83.216	83.081	84.383	83.147	83.994	82.265	80.827	80.014	80.758
7	87.796	86.084	86.068	87.123	86.840	86.618	85.145	83.894	85.576	87.123
8	85.113	85.409	85.769	86.675	85.852	85.267	82.674	82.558	83.359	86.459
9	91.114	90.684	90.437	90.518	90.168	88.503	89.255	88.024	88.827	89.259
10	93.718	93.057	92.360	92.848	92.780	91.053	91.003	90.670	90.619	91.461
11	95.316	95.202	94.380	94.507	94.047	93.144	93.496	92.958	92.845	93.779
12	95.446	95.455	94.792	94.699	94.654	94.181	94.102	93.775	93.866	94.556
13	96.891	96.927	96.777	96.617	96.320	95.809	96.134	95.823	95.685	96.539
14	97.218	97.261	97.151	97.452	97.163	96.687	96.797	96.786	96.615	97.053
15	97.767	97.783	97.419	97.454	97.698	97.504	97.496	97.498	97.399	97.545
16	98.099	98.132	97.698	97.656	97.778	97.951	98.064	97.733	97.929	98.258
17	98.685	98.491	98.379	98.149	98.006	98.138	98.429	98.531	98.473	98.461
18	98.023	98.147	97.321	97.183	96.756	97.314	97.811	98.589	98.774	98.707
19	92.275	92.152	89.655	86.621	87.213	86.749	89.011	94.159	94.402	95.488
20	47.867	44.891	45.771	48.792	49.254	52.656	56.671	55.318	55.488	61.014
21	66.329	62.153	64.849	65.584	65.934	66.746	68.829	64.210	65.048	69.403
22	71.000	70.906	71.359	72.459	70.938	72.384	74.712	71.078	69.912	74.761
23	75.066	72.371	72.074	70.027	69.697	71.042	70.923	69.253	70.403	76.649
24	74.557	73.092	71.183	76.858	79.141	80.955	80.402	76.235	75.989	82.291
25	80.536	78.835	80.103	82.139	84.527	87.178	85.671	81.862	81.512	85.250
26	72.801	67.682	64.621	60.300	58.254	60.948	61.056	62.734	62.337	70.408
27	67.906	64.910	62.447	63.733	68.800	67.441	71.356	68.412	68.279	75.360
28	73.746	69.420	64.309	62.148	63.376	68.676	70.492	65.349	65.420	77.300
29	72.183	69.579	72.253	67.190	59.829	72.219	70.091	72.558	69.822	79.017
30	34.112	32.910	26.447	18.035	12.121	14.945	17.238	16.452	24.559	29.927
30+	29.848	28.691	27.379	28.780	35.948	40.550	41.631	41.414	51.282	54.212
UNK	71.034	71.857	68.229	69.578	70.111	46.788	54.431	74.342	66.471	75.674
TOTAL	66.091	73.459	75.995	76.417	77.227	79.355	82.082	80.337	80.676	82.329

Table 2.9

CONTINUATION RATES FOR ARMY ACTIVE DUTY ENLISTED PERSONNEL

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	63.753	83.719	83.312	80.521	80.577	81.016	84.712	84.946	84.203	83.269
2	21.177	44.868	62.282	62.535	70.229	80.763	88.230	87.491	88.440	86.544
3	23.438	36.773	35.840	43.670	45.452	43.500	48.180	49.719	53.000	61.647
4	59.414	68.076	75.679	82.232	79.409	73.205	74.713	65.223	64.984	71.480
5	78.458	79.829	81.987	87.384	87.022	86.584	87.099	89.192	87.953	89.628
6	80.051	80.868	82.205	84.827	86.180	83.789	81.999	83.438	82.877	83.556
7	85.399	85.376	85.885	87.712	87.709	85.452	83.366	80.138	82.311	84.628
8	85.846	83.854	84.361	86.023	83.749	82.038	84.122	81.732	84.070	86.892
9	89.078	87.432	87.269	88.156	86.453	85.044	88.116	89.110	89.118	89.370
10	93.996	91.927	91.689	92.030	91.191	89.047	90.771	91.669	90.908	92.113
11	93.517	93.250	92.279	92.700	91.364	90.618	92.240	93.303	92.599	92.972
12	94.475	92.920	93.088	93.341	92.073	91.530	92.974	93.399	93.486	94.247
13	96.574	95.594	95.281	95.453	94.051	93.628	94.785	94.386	94.638	95.481
14	96.175	95.914	96.101	95.733	95.274	94.812	96.025	96.288	95.913	96.552
15	96.620	96.410	96.376	96.314	96.468	96.314	96.849	97.290	96.520	97.474
16	97.638	97.051	97.148	97.621	96.977	97.114	97.846	98.011	97.660	97.965
17	97.620	97.450	97.835	97.784	97.576	97.296	98.145	98.521	97.913	98.057
18	97.403	97.746	97.884	98.143	98.185	98.230	98.618	98.643	98.660	98.506
19	97.156	96.981	97.882	97.982	97.910	98.275	98.576	98.556	98.555	98.610
20	50.692	49.837	44.727	49.885	45.300	49.903	56.232	55.960	57.372	61.567
21	61.050	59.307	60.047	65.114	58.285	66.870	65.278	64.988	63.291	66.087
22	64.496	69.977	68.748	72.221	67.543	75.412	76.556	73.348	70.720	73.954
23	70.591	70.374	69.722	75.073	71.890	78.506	77.024	73.956	73.437	75.839
24	66.689	68.130	65.178	72.403	70.927	79.562	80.170	76.385	75.209	78.804
25	73.808	74.769	76.084	79.744	81.506	84.707	86.125	81.296	80.967	82.624
26	67.657	64.021	64.184	68.038	69.444	73.534	78.821	75.371	72.497	78.094
27	57.216	58.384	55.535	64.664	62.903	68.614	69.093	68.516	68.670	72.423
28	61.364	62.796	62.631	73.122	72.408	77.899	77.995	77.863	75.306	79.370
29	62.924	60.664	65.816	68.627	59.594	72.115	70.028	74.528	73.777	78.261
30	33.469	34.525	23.883	20.313	11.607	12.928	13.263	10.236	16.239	8.800
30+	34.429	33.054	28.512	38.258	36.527	18.519	44.186	34.328	35.417	24.528
UNK	63.410	72.014	58.730	64.197	57.390	23.780	34.906	53.265	35.941	24.825
TOTAL	51.122	68.387	72.897	73.306	74.812	76.751	79.854	78.130	78.669	81.713

Table 2.10

CONTINUATION RATES FOR NAVAL ACTIVE DUTY ENLISTED PERSONNEL

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	85.227	84.845	83.762	80.183	84.422	84.143	86.985	88.151	89.164	88.642
2	67.878	67.457	75.891	75.336	78.435	79.761	88.867	89.392	90.590	88.427
3	84.443	85.537	84.331	72.635	66.183	74.806	83.925	81.872	83.398	81.467
4	27.442	26.580	34.166	41.727	45.339	47.076	49.935	49.464	45.925	49.999
5	82.586	83.373	81.321	85.493	89.162	89.104	86.939	80.242	76.659	80.918
6	80.494	76.159	73.972	75.869	75.689	76.361	75.369	76.977	75.643	74.209
7	88.398	88.462	87.565	89.200	91.392	90.230	89.405	87.671	88.636	88.807
8	87.370	88.187	88.974	89.228	88.459	86.501	80.973	81.259	82.571	84.945
9	89.512	91.004	90.538	90.487	91.379	87.161	85.752	85.692	87.076	89.017
10	90.996	91.736	90.248	91.383	91.932	88.652	88.272	86.952	87.403	88.693
11	95.488	95.776	94.382	94.256	94.843	93.765	93.741	93.418	93.405	93.580
12	95.920	96.856	95.630	94.729	95.910	94.884	93.541	94.075	93.787	93.749
13	96.518	97.551	96.963	96.419	96.640	95.582	95.983	95.681	95.371	96.623
14	97.095	97.831	97.344	97.713	97.493	96.236	96.078	96.084	95.726	96.217
15	97.465	98.086	97.549	97.325	97.527	97.102	97.014	96.618	97.106	96.415
16	97.792	98.073	97.181	96.583	97.397	97.364	97.353	96.589	97.121	97.653
17	98.543	98.528	97.971	97.415	97.294	97.738	97.859	97.922	97.838	97.896
18	96.766	96.155	94.241	93.203	92.904	94.143	95.245	97.408	97.907	97.873
19	65.434	71.636	64.340	62.384	60.368	64.288	67.893	82.735	82.466	86.439
20	47.652	50.499	48.629	48.816	50.940	55.891	57.033	55.921	51.326	56.036
21	63.312	65.057	64.918	60.683	62.943	66.460	67.482	62.452	66.695	70.140
22	67.420	72.210	68.823	66.913	66.012	68.223	69.171	67.482	68.056	71.668
23	73.743	75.800	77.413	71.873	72.789	74.964	73.128	70.601	72.340	77.355
24	77.203	81.460	77.749	80.865	78.358	78.071	78.544	76.653	74.071	82.736
25	84.444	86.924	83.754	81.311	83.706	84.274	80.822	80.769	79.617	82.891
26	73.213	81.202	75.054	73.466	72.764	77.929	72.443	72.458	73.700	77.486
27	77.554	82.706	80.979	80.029	81.818	75.000	76.201	78.824	75.802	83.740
28	88.364	89.845	88.319	84.346	83.957	82.270	90.244	87.179	83.831	91.154
29	80.774	83.748	82.661	73.248	63.115	75.322	75.000	79.054	68.404	80.000
30	22.222	33.140	29.279	26.812	17.131	20.522	25.429	24.157	31.624	43.128
30+	11.330	31.847	43.369	43.701	40.541	54.483	46.667	50.327	61.864	71.171
UNK	0.000	0.000	0.000	71.582	70.940	73.259	83.030	77.228	80.925	0.000
TOTAL	75.660	74.607	77.785	76.688	77.843	79.612	82.554	81.714	81.158	81.328

Table 2.11

CONTINUATION RATES FOR MARINE CORPS ENLISTED PERSONNEL

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	81.596	83.980	84.382	83.751	81.165	86.131	86.044	86.182	89.166	88.723
2	49.189	57.777	56.126	65.991	66.062	78.887	86.993	89.110	90.480	88.102
3	57.532	57.674	65.275	66.571	64.024	71.992	75.406	68.064	73.314	72.967
4	29.293	30.188	37.140	39.392	39.365	37.931	36.399	32.797	38.089	42.232
5	60.014	63.990	76.076	77.091	78.559	78.045	77.085	77.007	76.464	74.446
6	72.980	75.071	80.308	81.015	81.090	79.112	79.421	78.079	81.856	84.426
7	75.271	78.500	83.619	83.348	83.795	82.259	79.307	77.546	82.370	82.379
8	82.861	85.284	84.410	84.526	85.993	86.072	79.328	76.573	83.228	85.772
9	87.616	80.648	82.961	79.149	81.722	80.364	79.463	79.210	87.165	88.793
10	80.930	78.024	80.035	81.356	81.055	81.730	79.328	83.847	88.713	91.338
11	88.673	88.075	91.184	90.632	89.170	90.079	89.736	90.281	92.420	93.937
12	92.836	91.509	91.135	91.697	90.809	91.443	91.171	93.063	91.692	92.808
13	94.020	93.012	92.493	93.443	93.677	93.622	93.132	94.740	94.534	96.031
14	93.685	93.990	93.441	94.676	94.097	95.342	94.874	96.195	95.471	95.729
15	94.413	94.293	95.391	95.415	94.842	96.607	95.643	96.604	97.459	98.421
16	94.059	95.767	96.124	96.272	96.077	96.923	97.059	97.371	98.054	98.764
17	94.127	96.011	95.952	97.419	96.244	97.570	97.781	98.382	98.382	99.207
18	94.444	95.659	97.445	97.210	96.994	97.866	97.973	98.153	98.558	99.179
19	87.399	79.022	83.028	85.635	84.350	86.015	88.641	97.307	96.824	97.463
20	51.816	45.483	44.486	53.347	45.599	51.407	56.969	55.675	54.663	63.431
21	59.170	59.566	62.289	67.645	57.548	69.097	68.103	66.391	65.557	70.053
22	63.894	63.178	72.296	76.778	61.998	73.293	73.256	74.262	72.064	75.734
23	66.068	72.517	77.457	79.634	72.176	79.863	75.815	76.018	75.862	79.653
24	67.598	76.159	78.010	80.682	75.806	81.711	79.070	75.912	82.493	84.644
25	74.820	75.815	85.217	86.709	81.106	85.837	85.766	84.249	87.500	86.268
26	74.052	62.783	77.818	76.684	69.697	77.070	77.723	78.481	75.546	79.459
27	63.265	74.742	74.457	75.336	71.711	82.143	76.230	83.019	75.532	82.558
28	71.078	74.074	69.231	74.126	67.836	78.409	78.889	81.250	84.615	81.818
29	74.118	79.825	80.822	67.308	64.078	72.180	86.765	77.778	82.500	87.037
30	36.364	31.250	27.273	27.869	25.397	25.000	19.192	23.214	41.071	51.563
30+	23.333	17.143	30.000	28.205	35.714	48.649	40.741	35.484	45.833	44.118
UNK	30.162	65.398	83.140	75.000	0.000	0.000	0.000	0.000	0.000	0.000
TOTAL	62.557	67.512	69.267	72.261	71.128	76.225	77.640	74.643	77.861	78.442

Table 2.12

CONTINUATION RATES FOR AIR FORCE ENLISTED PERSONNEL

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	89.055	89.856	85.918	85.389	87.449	89.083	89.263	88.142	87.337	88.757
2	91.916	90.060	86.033	84.649	86.065	85.894	88.716	88.906	90.069	90.767
3	86.604	88.201	72.120	85.334	81.179	79.718	86.303	88.921	92.548	93.088
4	29.514	31.817	33.876	44.902	44.189	55.686	63.128	49.498	47.979	52.142
5	88.807	90.435	90.762	90.154	89.066	85.778	87.010	84.239	84.015	84.687
6	95.329	93.583	92.100	90.672	88.333	92.011	91.184	81.261	79.212	82.532
7	92.539	86.753	85.781	85.939	83.961	85.691	85.190	88.236	88.366	90.848
8	82.696	84.243	85.083	86.113	86.440	87.068	83.790	85.606	83.049	87.313
9	95.391	95.554	95.200	95.328	95.157	94.773	94.818	91.685	90.117	89.423
10	97.882	97.478	96.945	97.119	96.981	96.149	95.011	93.610	93.967	92.846
11	97.447	97.567	96.784	96.882	96.503	95.501	95.031	92.749	92.732	94.843
12	96.472	96.741	96.180	96.274	96.339	96.204	95.873	94.022	94.575	95.596
13	98.292	98.395	98.241	98.219	98.388	98.138	97.810	97.265	96.956	97.525
14	98.787	98.923	98.677	98.820	98.942	98.701	98.262	97.954	97.915	98.165
15	99.198	99.152	98.946	99.002	99.016	98.942	98.544	98.492	98.387	98.203
16	99.145	99.202	98.983	99.136	99.155	99.118	98.897	98.402	98.773	99.005
17	99.449	99.396	99.349	99.364	99.603	99.242	99.120	99.019	99.375	99.132
18	99.362	99.468	99.541	99.500	99.528	99.495	99.299	99.451	99.543	99.415
19	99.233	99.327	99.406	99.318	99.299	99.407	99.355	99.406	99.627	99.429
20	46.817	40.836	45.709	48.139	51.109	53.207	56.811	54.147	56.925	63.312
21	70.774	62.657	68.310	66.931	70.287	66.575	71.883	64.344	65.827	71.498
22	77.322	71.700	72.686	73.789	74.974	72.765	76.531	71.087	70.034	77.708
23	80.043	73.038	72.320	67.624	67.485	67.465	67.760	65.669	67.130	76.508
24	79.551	74.659	73.009	78.423	82.150	82.721	81.015	76.046	76.506	84.111
25	86.023	79.066	81.503	83.118	86.394	88.693	86.630	82.120	82.026	87.581
26	77.960	67.176	60.353	50.503	48.856	52.669	52.358	49.340	55.460	64.230
27	75.854	62.034	59.358	55.411	68.398	62.925	70.992	63.784	63.636	73.413
28	80.422	63.333	50.524	42.117	45.056	54.221	57.810	51.997	51.552	67.731
29	76.415	68.517	69.147	58.966	55.733	69.388	63.253	66.460	65.976	77.331
30	41.839	31.537	26.432	6.532	3.509	9.016	12.647	15.640	25.463	38.341
30+	33.333	24.575	16.872	4.943	9.524	21.429	14.286	26.087	43.182	54.667
UNK	95.228	87.097	92.582	83.108	89.110	89.100	88.235	90.783	88.300	88.612
TOTAL	82.144	80.059	80.233	81.475	82.062	83.919	86.481	84.215	84.092	85.697

Table 2.13

OVERALL CONTINUATION RATES FOR
DOD ENLISTED PERSONNEL

	Army	Navy	Marine Corps	Air Force	DoD
1971	51.1	75.7	62.6	82.1	66.1
1972	68.4	74.6	67.5	80.1	73.5
1973	72.9	77.8	69.3	80.2	76.0
1974	73.3	76.7	72.3	81.5	76.4
1975	74.8	77.8	71.1	82.1	77.2
1976	76.8	79.6	76.2	83.9	79.4
1977	79.9	82.6	77.6	86.5	82.1
1978	78.1	81.7	74.6	84.2	80.3
1979	78.7	81.2	77.9	84.1	80.7
1980	81.7	81.3	78.4	85.7	82.3

required, and increased the proportion of the force with longer commitments. In addition, the average length of the first term of service was further increased by the volunteer force policy, which completely eliminated two-year draftees and offered more attractive pay and training opportunities for longer commitments.

First-term retention rates have also increased dramatically since FY75 because volunteers enter with more taste for service life. These factors led to higher overall force-wide continuation rates. The higher continuation rates are dramatically illustrated by tracking individuals who entered in FY71-72. During this period, enlistments could be classified as draft-motivated or nondraft-motivated depending on an individual's lottery number. Table 2.14 shows the percentage of individuals left in service from those FY71-72 cohorts. As the data

Table 2.14

PERCENTAGE OF FY71-72 ENLISTED ACCESSION COHORTS REMAINING

Years Since Accession	High School Graduates		All Enlistments	
	Low Lottery 1-90	High Lottery 271-366	Low Lottery 1-90	High Lottery 271-366
1	88.6	87.3	86.9	84.5
2	74.7	87.3	72.1	70.5
3	59.5	61.2	56.5	55.3
4	33.0	39.1	30.3	34.8
5	17.6	25.1	17.1	22.3
6	15.8	22.6	15.3	20.1
7	13.6	19.9	13.2	17.6
8	11.4	16.9	11.0	14.9

indicate, volunteers (high lottery numbers) have significantly higher long-term retention rates than do draft-motivated personnel. These higher retention rates have in turn contributed to lowered accession requirements (see Table 2.15). The lower accession requirements for a given force size enable the services to raise enlistment quality standards, and will be particularly important to maintain during the coming decline in the 17-21 year old population pool and improving economy.

Overall continuation rates for the four services generally follow an upward trend, with the most pronounced trend being for the Army and Marine Corps. These services were most affected by the Vietnam build-up and the influence of the draft. However, even the Navy and Air Force show a higher overall continuation rate after 1976--mainly due to the higher reenlistment rates of volunteers.

Table 2.15

NONPRIOR SERVICE ENLISTED ACCESSION LEVELS

(Thousands of personnel)

Fiscal Year	Air Force	Navy	Marine Corps	Army	DoD
71	96	78	56	314[a]	544[a]
72	86	87	58	187[b]	418[b]
73	94	95	52	216[c]	455[c]
74	74	79	48	182	383
75	76	101	58	185	419
76	73	93	51	180	397
77	73	101	45	168	387
78	68	80	40	124	311
79	67	80	40	129	315
80	72	88	42	158	360
81	77	92	41	118	328
82	68	80	38	120	306

[a]Includes 2,064 inductions.

[b]Includes 156,075 inductions.

[c]Includes 35,678 inductions.

One effect of the end of the draft and the higher volunteer era reenlistment rates has been a structural change in the distribution of service personnel by years of service experience (see Table 2.16). For total active enlisted personnel, the mix of junior[4] to career personnel has shifted from a 61/39 mix to a 58/42 mix. Perhaps more important is

[4]We have defined junior level personnel to be those in the first three years of service.

Table 2.16

PERCENTAGE OF ENLISTED PERSONNEL IN YEAR OF SERVICE GROUPS

YOS	72	74	76	78	80
			DoD		
1-4	61.2	60.7	58.9	58.2	57.6
5+	38.8	39.3	41.1	41.8	42.4
5-10	14.8	16.9	20.8	22.0	23.1
11+	24.0	22.4	20.3	19.8	19.3
			Army		
1-4	65.7	67.4	64.0	61.8	60.3
5+	34.3	32.6	36.0	38.2	39.7
5-10	15.2	15.3	20.3	22.0	24.0
11+	19.1	17.3	15.7	16.2	15.7
			Navy		
1-4	62.3	59.5	57.9	58.8	57.9
5+	37.7	40.5	42.1	41.2	42.1
5-10	15.0	17.4	20.9	21.7	23.0
11+	22.7	23.1	21.2	19.5	19.1
			Marine Corps		
1-4	75.1	74.8	74.3	74.5	72.1
5+	24.9	25.2	25.7	25.5	27.9
5-10	11.4	13.8	15.8	15.9	18.0
11+	13.5	11.4	9.9	9.6	9.9
			Air Force		
1-4	51.1	48.7	47.2	46.5	47.9
5+	48.9	51.3	52.8	53.5	52.1
5-10	15.0	19.3	23.3	24.6	23.8
11+	33.9	32.0	29.5	28.9	28.3

the dramatic change in the structure of the career force. Younger career personnel with 5 to 10 YOS have increased from 14.8 to 23.1 percent of the force, while the percentage of older career personnel has declined from 24.0 to 19.3 percent of the force. Each of the services shows similar trends in both first-term career mix as well as the mix of junior to senior level careerists. In the absence of policy intervention, the higher reenlistment rates of an all-volunteer force essentially provide a larger career force than does a draft. Two advantages of this mid-career bulge is the greater selectivity available for NCOs or the potential to use this bulge as the base to build a larger force size. It also raises an important policy issue of how many individuals should be continued to retirement.

Retention rate differences by YOS (Tables 2.3-2.7) show fairly well-known patterns. In the first two years of service, retention rates are determined by attrition prior to end of term of service (ETS). This attrition is primarily determined by the quality of the enlistment cohort. Attrition tends to be higher in the Army, where quality is lowest. For DoD enlisted personnel since 1977, first-year attrition has been between 13-14 percent,[5] while second-year attrition has been between 10-12 percent.

Continuation rates between 3 and 12 years of service are dominated by first-, second-, and third-term reenlistment decisions. The lowest continuation rates are experienced at the first-term decision, which can occur as early as the end of the second year and as late as the sixth year. This reenlistment behavior is more clearly shown if continuation rates are calculated only for those individuals having an ETS during the year (see Table 2.17). For DoD enlisted personnel, these continuation rates generally rise between 3 and 20 years of service, illustrating both the effects of self-selection and the pull of the military retirement system.

[5]First-year attrition is somewhat underestimated here for the first year only because some individuals enlist and leave during the fiscal year. These individuals do not appear on our file.

Table 2.17

CONTINUATION RATES FOR ETS DOD ENLISTED PERSONNEL

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	22.118	41.720	39.293	34.148	41.728	18.511	40.143	29.529	39.626	35.666
2	4.056	7.713	11.627	12.620	19.135	16.044	35.237	38.664	33.557	32.055
3	8.437	17.808	17.990	23.130	17.607	27.126	24.608	25.068	29.259	35.621
4	12.242	13.776	16.955	22.370	22.272	26.809	27.110	24.080	28.109	34.740
5	27.962	32.017	37.821	46.272	45.931	45.408	41.992	39.866	38.616	46.798
6	36.764	40.353	42.910	47.781	45.423	43.626	39.097	37.831	44.254	47.984
7	45.579	52.549	53.573	57.707	56.072	56.529	50.559	46.393	52.362	60.353
8	55.094	63.346	63.114	66.019	62.525	60.119	54.439	50.234	54.056	62.316
9	65.459	65.349	66.026	67.996	66.090	62.318	60.445	57.780	60.799	68.252
10	70.082	73.221	71.521	74.883	73.125	69.769	68.544	66.567	68.780	73.744
11	79.595	83.746	81.655	82.898	79.727	79.952	77.780	75.007	76.950	80.459
12	86.261	90.757	89.116	89.214	88.133	86.589	83.945	82.333	82.998	85.397
13	89.307	91.089	89.562	90.281	87.125	85.499	84.214	83.675	85.107	89.674
14	90.420	92.336	91.431	92.158	89.273	88.612	88.963	88.954	88.972	91.200
15	93.339	94.982	93.613	93.710	93.610	93.182	93.216	92.383	92.898	94.015
16	94.259	97.269	96.005	95.433	96.027	96.773	96.704	96.172	96.237	96.474
17	95.772	96.887	96.155	95.168	93.303	94.565	96.431	96.425	96.009	96.137
18	93.780	95.820	94.061	91.815	92.970	94.387	95.615	96.006	96.114	95.905
19	70.146	71.812	65.978	63.899	72.533	77.588	79.899	84.543	83.752	87.171
20	32.606	28.718	29.372	32.254	29.771	33.902	35.069	33.907	34.967	40.183
21	45.542	37.877	43.653	46.197	39.951	46.292	39.879	35.450	36.867	41.537
22	48.289	39.902	39.229	51.622	40.420	48.923	50.319	43.951	46.461	52.247
23	55.878	47.993	54.920	53.789	50.314	52.451	44.280	42.024	46.291	56.659
24	54.859	57.898	56.524	59.016	56.457	67.274	61.206	54.725	56.077	64.743
25	59.294	58.147	58.214	61.780	58.314	73.235	69.749	64.242	65.394	69.763
26	53.323	42.988	35.050	28.794	29.971	39.415	34.813	37.372	36.594	46.772
27	42.332	42.395	40.746	45.701	48.899	53.039	47.107	45.731	51.016	56.600
28	43.466	47.300	38.155	29.975	29.965	42.702	36.648	30.250	35.411	52.705
29	43.740	37.285	41.408	40.074	34.247	46.092	49.826	51.542	50.810	61.575
30	15.385	13.538	10.109	7.612	6.208	9.320	11.359	10.797	17.837	19.842
31+	13.143	9.262	9.079	9.959	13.525	21.333	17.460	26.471	33.929	39.063
1+	24.265	32.508	28.745	26.421	23.756	5.882	16.667	15.385	29.268	23.810
TOTAL	17.082	28.965	34.563	36.887	36.599	41.097	41.485	38.198	41.855	48.858

The continuation behavior of groups with 3 to 19 YOS not having an ETS (see Table 2.18) shows stable and high continuation rates. Once past the first term, non-ETS separations can occur by death, disability, hardship, AWOL, or nonsatisfactory service. Attrition of this type is a small proportion of overall losses, and probably has only small non-random components. Continuation rates fall at 20 YOS with retirement eligibility and are fairly uniform across services.

STATISTICAL TESTS FOR THE PRESENCE OF NONRANDOM FACTORS

A common method used by manpower analysts to forecast the population of a manpower group is to disaggregate the group into "homogeneous" subgroups and assume a future retention or continuation rate equal to the rate for the previous time period.

$$P^{t+1} = \sum_i P_i^t \, r_i^{t,\, t-1}$$

where P^{t+1} = population of group in time period $t + 1$

P_i^t = population of homogeneous subgroup i in time period t

$r_i^{t,\, t-1}$ = retention rate of subgroup i between time period t and $t - 1$.

The underlying assumption of this technique is that homogeneous groups can be found for which retention rates are stable over time and are described by a distribution like the binomial distribution. Differences in retention rates between subgroups are recognized, but retention rates are assumed stable over time.

Probably the sole advantage of this type of model is its simplicity. Forecasting from this model requires only personnel records from two previous years to calculate r and a current population profile. In military manpower applications, the force is typically disaggregated by demographic characteristics, educational and mental category, and MOS. Retention rates similar to those displayed earlier are then

Table 2.18

CONTINUATION RATES FOR NON-ETS DOD ENLISTED PERSONNEL

YOS/YEAR	71	72	73	74	75	76	77	78	79	80
1	73.832	85.426	84.257	82.361	82.964	83.995	86.403	86.726	86.778	86.384
2	69.859	85.868	86.181	84.852	83.641	87.073	88.772	88.936	90.238	89.189
3	81.581	84.933	80.413	85.667	84.031	85.327	89.848	90.722	92.409	92.219
4	52.924	85.944	89.257	90.337	89.217	90.252	91.031	91.235	90.536	91.536
5	86.592	89.348	91.551	91.593	92.684	92.620	92.927	92.582	92.808	92.345
6	92.740	92.951	93.988	94.303	94.037	94.012	94.803	95.174	95.259	95.705
7	92.723	93.888	94.618	94.721	95.077	94.658	95.207	95.161	95.640	95.819
8	89.721	94.895	95.387	95.333	95.606	95.631	95.886	95.803	95.976	96.629
9	95.085	96.357	96.400	96.295	96.207	96.078	96.574	96.307	96.524	96.895
10	96.556	96.680	96.929	97.032	96.972	96.372	96.520	96.536	96.447	97.038
11	96.729	97.252	97.178	97.036	97.113	96.674	97.007	97.032	97.028	97.336
12	96.622	97.491	97.517	97.279	97.440	97.123	97.310	97.412	97.476	97.648
13	97.639	97.872	98.245	97.922	97.967	97.649	97.843	97.793	97.631	98.033
14	98.091	98.289	98.380	98.384	98.327	97.829	97.865	97.911	97.860	98.264
15	98.413	98.524	98.498	98.305	98.461	98.193	98.081	98.303	98.261	98.383
16	98.529	98.502	98.411	98.427	98.365	98.350	98.446	98.203	98.428	98.813
17	98.914	98.870	98.858	98.655	98.608	98.569	98.658	98.785	98.825	98.832
18	98.409	98.504	97.899	97.853	97.145	97.619	98.030	98.835	99.070	99.046
19	94.290	94.603	92.934	90.705	89.666	88.293	90.586	95.628	96.224	96.962
20	50.011	61.086	60.384	64.743	67.272	69.846	72.210	71.088	72.307	76.162
21	70.391	78.083	77.454	77.240	78.642	74.900	79.260	75.751	76.861	81.036
22	74.532	78.927	79.916	77.968	80.902	78.331	80.434	77.849	77.241	81.609
23	78.329	81.939	82.941	82.837	82.896	82.145	82.955	80.185	81.067	84.903
24	78.088	83.917	84.179	86.466	88.001	86.783	86.532	83.625	83.682	89.120
25	84.059	88.384	88.749	87.057	91.294	89.939	88.802	86.006	86.006	89.681
26	77.423	76.819	78.382	76.510	79.651	82.049	83.358	79.289	80.906	85.431
27	74.389	79.640	80.717	78.675	82.786	77.051	82.974	80.360	78.719	86.023
28	78.069	81.378	83.305	82.358	82.826	80.793	84.217	82.855	82.419	87.552
29	77.176	80.885	83.548	77.368	73.027	80.048	78.329	80.095	78.519	86.758
30	42.285	54.342	54.921	47.093	34.799	40.816	49.444	51.546	61.458	72.727
31+	36.842	50.712	54.990	57.012	61.395	60.993	70.093	61.417	67.213	67.586
[illegible]	79.619	80.920	75.215	75.543	74.473	51.931	55.603	74.908	69.217	76.458
TOTAL	78.857	88.492	87.807	87.773	87.691	88.887	90.596	90.990	91.510	91.339

REPRODUCED AT GOVERNMENT EXPENSE

Table 3.3

FORECASTING ACCURACY FOR NAVY ENLISTED PERSONNEL UNDER SIMPLE CONTINUATION RATE ASSUMPTION

	Mean Absolute Percentage Error/100			
Years of Service	One Year 71-80	One Year 76-80	Three Years 72-77	Five Years 72-75
1	0.020	0.016	0.175	0.267
2	0.036	0.037	0.187	0.227
3	0.064	0.044	0.160	0.188
4	0.086	0.056	0.145	0.119
5	0.037	0.052	0.053	0.090
6	0.022	0.018	0.067	0.141
7	0.012	0.010	0.064	0.124
8	0.019	0.029	0.062	0.096
9	0.015	0.014	0.036	0.065
10	0.013	0.010	0.028	0.059
11	0.005	0.001	0.021	0.052
12	0.009	0.006	0.020	0.033
13	0.007	0.006	0.015	0.020
14	0.005	0.003	0.011	0.040
15	0.004	0.004	0.011	0.242
16	0.005	0.005	0.036	0.220
17	0.002	0.001	0.186	0.203
18	0.010	0.010	0.156	0.194
19	0.067	0.070	0.125	0.196
20	0.049	0.053	0.104	0.164
21	0.044	0.052	0.081	0.113
22	0.032	0.024	0.063	0.133
23	0.035	0.037	0.049	0.105
24	0.038	0.043	0.084	0.111
25	0.025	0.024	0.099	0.193
26	0.047	0.035	0.055	0.510
27	0.044	0.046	0.145	
28	0.039	0.061	0.566	
29	0.095	0.089		
30	0.226	0.187		

Table 3.2

FORECASTING ACCURACY FOR ARMY ENLISTED PERSONNEL UNDER SIMPLE CONTINUATION RATE ASSUMPTION

	Mean Absolute Percentage Error/100			
Years of Service	One Year 71-80	One Year 76-80	Three Years 72-77	Five Years 72-75
1	0.039	0.017	0.289	0.265
2	0.131	0.031	0.138	0.202
3	0.109	0.083	0.122	0.194
4	0.076	0.065	0.122	0.172
5	0.020	0.016	0.085	0.107
6	0.017	0.013	0.051	0.034
7	0.019	0.030	0.022	0.028
8	0.023	0.029	0.033	0.037
9	0.013	0.012	0.033	0.042
10	0.012	0.013	0.029	0.033
11	0.009	0.010	0.028	0.025
12	0.008	0.007	0.019	0.013
13	0.007	0.007	0.012	0.012
14	0.005	0.006	0.007	0.010
15	0.004	0.007	0.009	0.018
16	0.004	0.004	0.010	0.188
17	0.003	0.005	0.009	0.194
18	0.002	0.001	0.121	0.192
19	0.002	0.001	0.083	0.187
20	0.071	0.053	0.096	0.226
21	0.051	0.024	0.126	0.250
22	0.051	0.035	0.141	0.307
23	0.035	0.025	0.156	0.357
24	0.046	0.030	0.155	0.374
25	0.026	0.025	0.157	0.396
26	0.046	0.056	0.159	0.332
27	0.044	0.017	0.145	
28	0.037	0.022	0.604	
29	0.071	0.039		
30	0.338	0.384		

Table 3.1

FORECASTING ACCURACY FOR DOD PERSONNEL UNDER SIMPLE CONTINUATION RATE ASSUMPTION

	Mean Absolute Percentage Error/100			
Years of Service	One Year 71-80	One Year 76-80	Three Years 72-77	Five Years 72-75
1	0.027	0.009	0.142	0.276
2	0.077	0.028	0.174	0.208
3	0.064	0.053	0.147	0.152
4	0.081	0.070	0.112	0.111
5	0.018	0.017	0.039	0.063
6	0.013	0.015	0.044	0.063
7	0.012	0.017	0.029	0.061
8	0.013	0.020	0.024	0.050
9	0.007	0.009	0.021	0.044
10	0.006	0.003	0.016	0.034
11	0.005	0.005	0.013	0.024
12	0.003	0.003	0.009	0.011
13	0.003	0.004	0.005	0.005
14	0.002	0.002	0.005	0.019
15	0.001	0.001	0.005	0.081
16	0.002	0.002	0.014	0.193
17	0.001	0.001	0.066	0.173
18	0.004	0.004	0.110	0.135
19	0.019	0.024	0.082	0.116
20	0.046	0.047	0.068	0.115
21	0.035	0.044	0.029	0.086
22	0.025	0.041	0.048	0.099
23	0.024	0.031	0.096	0.152
24	0.035	0.035	0.084	0.186
25	0.026	0.028	0.051	0.167
26	0.047	0.037	0.101	0.690
27	0.044	0.048	0.138	
28	0.059	0.065	0.750	
29	0.074	0.055		
30	0.235	0.173		

$$A_i^{71,79} = \frac{1}{9} \sum_{j=1}^{9} | E_{i,j}^1 |$$

$$A_i^{76,79} = \frac{1}{4} \sum_{j=6}^{9} | E_{i,j}^1 |$$

For a one-year forecast, two time periods have been summarized--FY71-79 and FY76-79. The latter time period removes the effect of draft-motivated personnel on first-term retention decision, and thus may be more indicative of accuracy in an all-volunteer environment. For three- and five-year forecasts, the summary statistics are given by

$$T_i^{72,77} = \frac{1}{6} \sum_{j=1}^{6} | E_{i,j}^3 |$$

$$T_i^{72,75} = \frac{1}{4} \sum_{j=1}^{4} | E_{i,j}^5 |$$

Tables 3.1 through 3.5 provide the forecasting errors by service and for DoD personnel.

FORECAST ERROR FORMULAS

Forecast errors for one-, three-, and five-year forecasts for the simple models can easily be derived and are given as follows:

$$E^1_{i,j} = \frac{C_{i,j} - C_{i,j+1}}{C_{i,j+1}}$$

$$E^3_{i,j} = \frac{\prod_{k=0}^{2} C_{i+k,j} - \prod_{k=0}^{2} C_{i+k,j+k+1}}{\prod_{k=0}^{2} C_{i+k,j+k+1}}$$

$$E^5_{i,j} = \frac{\prod_{k=0}^{4} C_{i+k,j} - \prod_{k=0}^{4} C_{i+k,j+k+1}}{\prod_{k=0}^{4} C_{i+k,j+k+1}}$$

where $E^n_{i,j}$ = error for the n year forecast of service cohort i in year j

$C_{i,j}$ = continuation rate for service cohort i in year j

Essentially, the above equations forecast for 1, 3, or 5 years using continuation rates from a given year, and then compare the forecast to the actual number of personnel present in the forecast year.

Estimates of forecasting accuracy can be made with the FY71-80 data. For a one-year forecast, estimates of accuracy can be made for FY71-79. For a three-year forecast, estimates can be made for FY71-77, and for a 5-year forecast, estimates can be made for FY71-75. Rather than provide forecasts for each YOS group for each service, summary statistics have been compiled. The mean absolute percentage error has been used to summarize the data.

III. HISTORICAL FORECASTING ACCURACY UNDER SIMPLE CONTINUATION ASSUMPTIONS

The results of the previous section imply that the presence of nonrandom factors is the dominant component of forecast errors, but the amount of influence of nonrandom factors varied considerably depending on YOS group and degree of disaggregation. Only for highly disaggregated groups with between 12 and 19 YOS did the random component seem to dominate. In the latter case, the accuracy of forecasts can be predicted by simple continuation models. In the case where nonrandom factors dominate, models which incorporate the nonrandom factors can probably be used to improve accuracy.

From a policy perspective, a better measure of predictive accuracy than deviation from binomial statistics is the percentage error in forecasts. The binomial theory imposes stringent standards of accuracy--especially for large groups--and nonadherence to binomial standards may still lead to acceptable forecasting errors from a policy perspective. In this section, the percentage errors in forecasts are calculated for simple continuation rate models.

The simplest model of retention decisions is to simply assume the retention rate will be equal in the future to the most recently measured rate. While these types of models have the virtue of being relatively simple, require minimum data, and guarantee continuity with past history--they are unlikely to predict well if nonrandom, noncyclic factors are present. Here we have calculated the historical accuracy of this forecasting technique, widely used in the 1971-1980 period. Small percentage errors would provide little motivation to incorporate more complex techniques into large-scale models. If large percentage errors emerge, their pattern will be important in determining the source of error as well as some idea of the expected improvement should behavioral models be incorporated.

Table 2.23

NUMBER OF DEVIATIONS (10% SIGNIFICANCE) FROM BINOMIAL DISTRIBUTION IN NINE YEAR TO YEAR ARMY RETENTION COMPARISONS

YOS	Total	White Male, Cat I[a] HS Grad	White Male, Cat II[a] HS Grad	White Male, Cat III[a] HS Grad	White Male, Cat IV[a] HS Grad
	Expected Number of Deviations from Binomial Distribution				
	1	1	1	1	1
	Actual Number of Deviations				
1	6	7	7	7	6
2	9	6	7	7	8
3	9	8	7	7	6
4	8	8	8	7	7
5	7	6	6	3	4
6	7	4	4	5	2
7	7	5	5	5	3
8	7	8	7	5	4
9	6	3	6	3	2
10	6	3	3	3	1
11	4	1	3	1	0
12	4	2	1	0	2
13	5	1	2	1	4
14	3	2	0	1	1
15	2	2	0	0	1
16	2	1	0	2	0
17	3	0	0	1	1
18	1	0	0	0	1
19	1	0	1	0	3
20	6	2	5	6	4
21	5	3	2	3	0
22	5	5	1	4	3
23	4	0	2	3	0
24	3	1	1	4	1
25	1	1	3	0	1
26	2	3	1	1	4
27	2	0	1	1	1
28	1	4	3	4	2
29	0	1	5	3	4
30	5	1	1	2	1
Total					

[a]Recruits are classified into Category I, Category II, Category III, and Category IV mental groups, based on scores received on the entrance examination (Armed Forces Qualifying Test, or AFQT). Category I receive scores of 80 and above; Category IV receive scores of 30 and below.

the same summary statistics for ETS groups, and Table 2.23 provides the statistics for more highly disaggregated groups in the Army. (Appendix B contains the full Z statistics for these tables.)

Disaggregation by service and ETS group improves the correspondence with binomial statistics. Groups having an ETS during the year generally show more deviation during YOS 4 through 19 than non-ETS groups. However even non-ETS groups in the years of service 12 through 19 do not correspond to predictions from binomial statistics.

The data show that further disaggregation by demographic, education, and mental category reduces the number of deviations somewhat, but there remain substantial differences from the expected number of deviations predicted by the binomial distribution. These differences are highest for the early years of service and gradually decrease until--for the most disaggregated groups--the binomial distribution seems to hold only for years of service 12 through 19. Other groups are clearly dominated by nonrandom factors.

Table 2.22

NUMBER OF DEVIATIONS (10% CONFIDENCE LEVEL) FROM BINOMIAL DISTRIBUTION IN NINE (FY71-80) YEAR TO YEAR RETENTION COMPARISON

	Army		Navy		Marine Corps		Air Force		DoD	
	No ETS	ETS	No ETS	ETS	No ETS	ETS	No ETS	ETS	No ETS	ETS
	Expected Number of Deviations from Binomial Distribution									
	1	1	1	1	1	1	1	1	1	1
YOS	Actual Number of Deviations									
1	8	6	9	2	7	4	8	6	8	7
2	9	9	9	7	9	6	7	1	9	8
3	7	9	6	7	8	8	9	5	9	8
4	8	8	7	9	7	6	7	8	8	7
5	7	7	7	7	5	5	7	3	7	7
6	5	7	8	6	3	4	4	7	6	9
7	6	7	4	3	5	5	7	8	6	7
8	5	7	4	[illegible]	1	4	6	6	5	8
9	5	6	6	6	3	4	4	5	4	7
10	4	6	3	7	1	5	5	1	2	9
11	4	4	3	3	1	5	4	4	4	8
12	4	4	3	4	1	4	2	4	2	7
13	4	5	2	4	1	2	3	3	5	6
14	4	3	3	5	0	0	3	1	3	4
15	6	2	4	1	2	0	3	1	3	3
16	4	2	4	3	3	1	3	2	3	5
17	3	3	2	3	4	1	[illegible]	0	1	6
18	1	1	8	3	3	0	[illegible]	0	6	6
19	3	1	7	8	4	5	[illegible]	3	9	8
20	6	6	6	6	7	5	4	7	8	8
21	6	5	7	5	4	4	7	7	7	8
22	6	5	5	3	4	5	7	6	8	7
23	6	4	3	3	1	3	8	6	3	8
24	5	3	4	3	3	1	5	5	6	7
25	3	1	1	2	2	1	7	4	7	3
26	4	2	2	4	2	2	4	7	5	6
27	1	2	4	2	0	3	7	4	6	6
28	2	1	3	2	3	0	6	6	3	7
29	4	0	6	5	2	1	5	3	6	4
30	2	5	2	4	0	2	2	4	4	[illegible]

Table 2.21

NUMBER OF DEVIATIONS (10% CONFIDENCE LEVEL) FROM BINOMIAL DISTRIBUTION IN NINE (FY71-80) YEAR TO YEAR RETENTION COMPARISONS

	Army	Navy	Marine Corps	Air Force	DoD
	Expected Number of Deviations from Binomial Distribution				
	1	1	1	1	1
YOS	Actual Number of Deviations				
1	8	8	7	8	8
2	8	9	8	7	9
3	9	9	7	9	9
4	8	8	8	9	8
5	8	8	4	7	8
6	9	7	6	9	8
7	6	7	6	6	6
8	8	7	6	8	6
9	6	6	6	3	6
10	7	6	5	6	6
11	6	3	3	5	6
12	4	6	1	4	4
13	4	5	2	2	5
14	2	4	0	1	4
15	3	5	1	1	2
16	4	6	1	4	3
17	4	3	4	4	3
18	2	7	2	1	6
19	3	8	5	2	7
20	7	6	6	9	7
21	6	6	4	8	6
22	7	3	3	5	7
23	5	3	3	4	5
24	5	2	3	6	7
25	3	3	1	7	8
26	6	4	2	7	6
27	3	3	4	7	6
28	2	3	1	6	5
29	3	5	2	5	6
30	4	3	1	7	6

would expect only one in ten (1 in 20, 1 in 100) comparisons to be rejected at the 10 (5, 1) percent confidence level if the means were all chosen from the same binomial distribution. The results for this row clearly indicate variations from nonrandom sources.

The summary statistics indicate strongly that large variations from binomial errors occur between 1 and 10 YOS. In the region 11 to 19 YOS, much less frequent deviations from binomial errors occur. However, even for 11 to 19 YOS, the frequency of deviation is larger than expected on a purely statistical basis. For 20 to 30 YOS, the frequency of deviation from binomial errors again increases.

This pattern is the expected pattern given the vesting structure and level of benefits in the military retirement system and the presence of economic factors in nonrandom sources of variation. The current vesting of military retirement at 20 YOS forces military personnel to make career decisions between the 4th and 12th year of service. Effective military pay which includes the present value of retirement benefits is large enough after a certain point to make it extremely unlikely that civilian pay could provide higher long-term compensation. Thus, personnel decisions are increasingly insulated (but never completely) from the cyclical variations in the civilian labor market, and between 12 and 19 YOS essentially random factors such as death and disability dominate the retention statistics.

Retention for groups not as strongly affected by the structure of military retirement will depend on the availability and wage level of civilian jobs that varied cyclically over the period 1971-1980. Thus, groups from 3 to 10 and 20 to 30 YOS will have military compensation whose level is much closer to civilian opportunities, and will thus show cyclical behavior as civilian opportunities change. Retention rates for personnel with 1 to 2 YOS probably deviate from random variation not because of economic factors, but simply because of differing cohort quality compositions.

The Z statistics for aggregate DoD personnel across services would be expected to show the largest deviation from binomial distributions. One question is the extent to which disaggregation of military personnel into more "homogeneous" groups will reduce these deviations. Table 2.21 shows the summary statistics for the four services, Table 2.22 provides

Table 2.20

STATISTICS FOR DOD ENLISTED PERSONNEL

YOS	1971	1972	1973	1974	1975	1976	1977	1978	1979	Number Significant at 10%	5%	1%
1	138.43	-15.11	-26.93	12.50	11.72	28.63	3.10	0.86	-4.59	8	8	8
2	168.68	83.98	6.93	39.47	61.61	76.62	1.66	13.54	-17.26	9	8	8
3	63.45	-54.87	23.08	-21.94	7.58	46.89	-8.16	30.72	30.43	9	9	9
4	-3.90	39.79	57.31	10.65	14.07	16.76	-43.20	-0.68	29.14	8	8	8
5	7.79	11.88	11.46	5.43	-6.88	-0.93	-10.26	-11.43	12.72	8	8	8
6	-4.77	-0.64	6.73	-6.16	4.30	-9.51	-7.63	-4.15	3.76	8	8	8
7	-7.62	-0.07	5.04	-1.48	-1.12	-7.41	-6.53	8.75	8.24	6	6	6
8	1.14	1.44	3.83	-3.65	-2.72	-11.16	-0.50	3.71	15.02	6	6	6
9	-1.93	-1.08	0.36	-1.61	-7.83	3.68	-5.63	3.73	2.21	6	5	4
10	-3.48	-3.34	2.29	-0.33	-8.34	-0.24	-1.68	-0.24	4.13	6	5	4
11	-0.73	-4.71	0.67	-2.35	-4.47	1.77	-2.86	-0.61	4.93	6	5	4
12	0.06	-4.11	-0.52	-0.24	-2.41	-0.40	-1.67	0.49	3.97	4	3	2
13	0.27	-1.13	-1.17	-1.96	-3.01	1.87	-1.82	-0.81	5.50	5	3	2
14	0.34	-0.87	2.41	-2.31	-3.31	0.70	-0.07	-1.08	2.90	4	4	2
15	0.14	-3.07	0.29	2.04	-1.59	-0.06	0.01	-0.69	1.03	2	2	1
16	0.34	-3.93	-0.36	1.05	1.52	1.01	-2.66	1.48	2.61	3	3	3
17	-2.53	-1.24	-2.26	-1.32	1.23	2.86	1.03	-0.55	-0.11	3	3	1
18	1.42	-8.45	-1.16	-3.19	4.12	4.08	7.43	2.00	-0.68	6	6	5
19	-0.69	-13.68	-14.22	2.38	-1.76	8.67	23.27	1.32	6.07	7	6	5
20	-9.15	2.57	9.06	1.32	8.54	9.54	-3.20	0.41	13.72	7	7	6
21	-9.58	5.84	1.51	0.76	1.72	3.99	-8.57	1.54	8.29	6	5	5
22	-0.15	0.88	2.03	-2.67	2.63	4.25	-6.02	-1.82	7.68	7	6	5
23	-3.70	-0.41	-3.37	-0.51	2.05	-0.19	-2.51	1.58	8.51	5	5	3
24	-2.18	-2.20	6.71	3.46	2.60	-0.80	-6.20	-0.33	8.21	7	7	5
25	-2.42	1.77	2.31	2.84	4.17	-2.22	-5.31	-0.49	5.10	8	7	4
26	-5.88	-3.32	-4.48	-1.65	2.25	0.11	1.62	-0.38	8.41	6	5	4
27	-2.93	-2.25	1.11	4.27	-0.96	2.90	-2.57	-0.11	5.82	6	6	4
28	-3.68	-4.09	-1.57	0.84	3.36	1.02	-3.16	0.05	8.16	5	5	5
28	-2.24	1.91	-3.39	-4.26	7.02	-1.16	1.17	-1.43	5.75	6	5	4
30	-0.93	-4.71	-5.60	-4.24	1.84	1.38	-0.44	3.65	2.43	6	5	4
Significant at												
10%	19	21	20	20	25	18	23	10	27			
5%	18	19	20	19	22	16	19	9	27			
1%	14	16	15	14	19	15	17	8	25			

$$Z = \frac{C_t - C_{t-1}}{SD/\sqrt{n}} = \frac{C_t - C_{t-1}}{\sqrt{\frac{pq}{n}}}$$

The hypotheses that C_t and C_{t-1} are from the same underlying distribution can then be tested at a given confidence level. Table 2.19 gives the relationship between Z and the confidence level. Larger Z values basically indicate a higher probability that the mean difference was not drawn from the same binomial distribution.

Table 2.20 displays Z values for active force enlisted personnel obtained from using consecutive year continuation rates. For instance, the entry in the row (YOS = 1) and column (1975) indicates that the difference in continuation rates between 1975 and 1976 was 11.72 times the binomial standard error, a highly unlikely result if both means were drawn from the same binomial distribution.

A summary of the Z statistics for DoD for each YOS is given at the right side of Table 2.20. Of the nine comparisons made in each row, the summary provides the number of comparisons which are rejected at confidence levels of 10, 5, and 1 percent. For the first row, eight of nine comparisons would be rejected at the 10 percent level. Since we

Table 2.19

RELATIONSHIP BETWEEN Z VALUE AND CONFIDENCE LEVELS

Z	Confidence level
.675	Larger mean difference will occur 50 percent of the time
1.15	Larger mean difference will occur 25 percent of the time
1.645	Larger mean difference will occur 10 percent of the time
1.96	Larger mean difference will occur 5 percent of the time
2.575	Larger mean difference will occur 1 percent of the time

applied repeatedly to obtain 1, 3, or 5 year forecasts for a given YOS group.

$$P_{YOS}^{t+5} = \sum_{i} P_{i,\ YOS-5}^{t} \prod_{j=1}^{5} r_{i,YOS-j}^{t,\ t-1}$$

where P_{YOS}^{t+5} = population of enlisted personnel with given YOS in time period t + 5.

$P_{i,\ YOS-5}^{t}$ = population of enlisted personnel in homogeneous group i with year of service equal to YOS - 5 at time period t.

$r_{i,\ YOS-j}^{t,\ t-1}$ = retention rate between time period t and t - 1 for homogenous group i with year of service equal to YOS - j.

The historical consistency of these data with binomial statistics can be estimated using the data described earlier. We will determine the extent to which the variation in retention rates by YOS between 1971-1980 is consistent with a binomial distribution. If consistent, then year to year accuracy can be predicted with the simple binomial model. If not consistent, the variation could be either larger or smaller than binomial. Smaller variation could indicate that retention decisions are intercorrelated--perhaps through manpower policy instruments. A simple example would be to offer higher bonus amounts later in a year to compensate for lower retention generated randomly earlier in the year. Larger variation may indicate the existence and extent of nonrandom factors influencing retention decisions.

A test commonly used to measure variation from a statistical distribution is to compare the ratio of the actual year to year variation with that predicted from the assumed statistical distribution.

Table 3.4

FORECASTING ACCURACY FOR MARINE CORPS ENLISTED PERSONNEL UNDER SIMPLE CONTINUATION RATE ASSUMPTION

	Mean Absolute Percentage Error/100			
Years of Service	One Year 71-80	One Year 76-80	Three Years 72-77	Five Years 72-75
1	0.019	0.010	0.190	0.261
2	0.072	0.040	0.132	0.194
3	0.058	0.057	0.145	0.161
4	0.078	0.097	0.105	0.164
5	0.034	0.012	0.089	0.122
6	0.025	0.024	0.106	0.049
7	0.028	0.030	0.075	0.062
8	0.032	0.058	0.037	0.026
9	0.037	0.031	0.060	0.041
10	0.029	0.042	0.037	0.041
11	0.014	0.012	0.026	0.047
12	0.010	0.013	0.020	0.048
13	0.008	0.010	0.023	0.051
14	0.008	0.007	0.021	0.051
15	0.008	0.010	0.021	0.157
16	0.006	0.005	0.020	0.273
17	0.009	0.004	0.087	0.261
18	0.006	0.003	0.147	0.257
19	0.039	0.033	0.134	0.264
20	0.099	0.069	0.140	0.240
21	0.065	0.029	0.156	0.293
22	0.076	0.023	0.135	0.285
23	0.054	0.026	0.102	0.213
24	0.054	0.045	0.102	0.258
25	0.037	0.018	0.111	0.305
26	0.077	0.027	0.111	0.441
27	0.077	0.086	0.204	
28	0.057	0.027	0.448	
29	0.093	0.098		
30	0.173	0.279		

Table 3.5

FORECASTING ACCURACY FOR AIR FORCE ENLISTED PERSONNEL
UNDER SIMPLE CONTINUATION RATE ASSUMPTION

	Mean Absolute Percentage Error/100			
Years of Service	One Year 71-80	One Year 76-80	Three Years 72-77	Five Years 72-75
1	0.016	0.010	0.120	0.247
2	0.017	0.014	0.203	0.159
3	0.068	0.038	0.196	0.171
4	0.123	0.126	0.152	0.122
5	0.015	0.014	0.060	0.069
6	0.035	0.049	0.030	0.070
7	0.021	0.017	0.033	0.072
8	0.021	0.035	0.036	0.060
9	0.008	0.015	0.039	0.055
10	0.007	0.011	0.032	0.038
11	0.009	0.013	0.022	0.025
12	0.006	0.010	0.014	0.015
13	0.003	0.004	0.009	0.011
14	0.002	0.003	0.007	0.008
15	0.001	0.002	0.004	0.002
16	0.002	0.003	0.003	0.195
17	0.002	0.002	0.002	0.172
18	0.001	0.001	0.120	0.140
19	0.001	0.001	0.085	0.107
20	0.074	0.066	0.085	0.080
21	0.070	0.073	0.054	0.097
22	0.044	0.060	0.059	0.103
23	0.040	0.045	0.109	0.099
24	0.044	0.046	0.105	0.328
25	0.038	0.036	0.123	0.346
26	0.099	0.078	0.234	1.472
27	0.109	0.091	0.313	
28	0.153	0.105	3.030	
29	0.095	0.075		
30	0.693	0.300		

ONE-YEAR FORECASTS

In the 1971-79 period, the greatest percentage errors in forecasting in each service occurred in the years of service 2 through 4 and 20 through 30, where average percentage errors are almost always less than 10 percent. For between 5 and 10 years of service, average percentage errors are usually less than 3 percent. In the YOS range 11 to 19, average percentage errors are less than 1 percent. For the first year of service, average percentage error does not exceed 4 percent for any service.

Forecasting accuracy should improve for the 1976-79 period around first-term retention because of the absence of draft-motivated personnel. The data generally show reduced average error rates for this period when compared to the 1971-79 period.

The somewhat surprising accuracy of one-year forecasts during a period marked by a rapidly changing economic environment and a policy environment marked by transition to an all-volunteer force can be attributed partly to a key structural parameter of the military manpower system--the term of service. Most military personnel have at least 3-year terms of service and some have up to 6-year terms. The result is that only about 20 to 25 percent of military personnel make an ETS decision annually (see Table 3.6). Thus, 75 percent of personnel are in a highly stable and fairly predictable non-ETS status. This is illustrated when accuracy is calculated for both ETS and non-ETS groups (see Tables 3.7 through 3.11). This accurate forecasting in the short term does not require highly accurate forecasting of ETS decisions. The remarkable accuracy of one-year forecasts hides a somewhat inaccurate forecast for ETS groups. One-year errors for ETS groups range from 10 to 30 percent for groups with 2 to 4 YOS.

Table 3.6

PERCENTAGE OF ENLISTED MILITARY PERSONNEL
HAVING AN ETS DECISION EACH YEAR

1971	Army	Navy	Marine Corps	Air Force	DoD
72	31.6	20.8	31.9	--	20.7
73	36.8	26.0	27.4	21.8	25.3
74	25.0	22.2	24.1	18.5	22.3
75	21.4	19.7	22.5	19.2	20.5
76	23.3	17.8	22.1	16.5	19.9
77	20.6	15.9	20.7	12.8	17.3
78	23.2	18.1	26.5	15.7	20.2
79	24.0	20.6	25.3	18.7	21.8
80	21.0	22.5	24.3	19.0	21.2

Table 3.7

A MEASURE OF FORECASTING ACCURACY UNDER A SIMPLE CONTINUATION ASSUMPTION FOR DOD ENLISTED PERSONNEL

	Mean Absolute Percentage Error/100					
	Non-ETS		ETS		Both Groups	
Years of Service	1971-80	1976-80	1971-80	1976-80	1971-80	1976-80
1	0.025	0.009	--	--	0.027	0.009
2	0.034	0.012	0.251	0.208	0.077	0.028
3	0.030	0.020	0.207	0.111	0.064	0.053
4	0.054	0.007	0.132	0.118	0.081	0.070
5	0.009	0.004	0.092	0.085	0.018	0.017
6	0.004	0.004	0.080	0.093	0.013	0.015
7	0.005	0.003	0.079	0.114	0.012	0.017
8	0.008	0.003	0.074	0.098	0.013	0.020
9	0.003	0.003	0.041	0.059	0.007	0.009
10	0.002	0.002	0.037	0.037	0.006	0.003
11	0.002	0.002	0.030	0.033	0.005	0.005
12	0.002	0.001	0.021	0.022	0.003	0.003
13	0.002	0.002	0.021	0.022	0.003	0.004
14	0.002	0.001	0.012	0.007	0.002	0.002
15	0.001	0.001	0.007	0.007	0.001	0.001
16	0.001	0.002	0.008	0.002	0.002	0.002
17	0.001	0.001	0.010	0.006	0.001	0.001
18	0.004	0.004	0.012	0.005	0.004	0.004
19	0.018	0.023	0.051	0.033	0.019	0.024
20	0.050	0.029	0.076	0.057	0.046	0.047
21	0.038	0.042	0.124	0.109	0.035	0.044
22	0.031	0.030	0.140	0.084	0.025	0.041
23	0.019	0.025	0.104	0.128	0.024	0.031
24	0.026	0.025	0.078	0.094	0.035	0.035
25	0.024	0.022	0.062	0.054	0.026	0.028
26	0.029	0.035	0.156	0.110	0.047	0.037
27	0.049	0.052	0.072	0.090	0.044	0.048
28	0.025	0.030	0.187	0.213	0.059	0.066
29	0.052	0.040	0.115	0.074	0.074	0.055
30	0.159	0.133	0.232	0.182	0.235	0.173

Table 3.8

A MEASURE OF FORECASTING ACCURACY UNDER A SIMPLE CONTINUATION ASSUMPTION FOR ARMY ENLISTED PERSONNEL

	Mean Absolute Percentage Error/100							
	Non-ETS		ETS		Both Groups		White Male, Mental Cat II, High School Graduate	
Years of Service	1971-80	1976-80	1971-80	1976-80	1971-80	1976-80	1971-80	1976-80
1	0.039	0.017	--	--	0.039	0.017	0.053	0.029
2	0.073	0.011	0.257	0.195	0.131	0.031	0.115	0.027
3	0.046	0.013	0.240	0.116	0.109	0.083	0.126	0.111
4	0.023	0.011	0.181	0.100	0.076	0.065	0.105	0.132
5	0.013	0.009	0.111	0.085	0.020	0.016	0.034	0.006
6	0.008	0.005	0.088	0.083	0.017	0.013	0.027	0.015
7	0.007	0.004	0.088	0.129	0.019	0.030	0.040	0.051
8	0.008	0.007	0.063	0.084	0.023	0.029	0.040	0.027
9	0.006	0.005	0.035	0.041	0.013	0.012	0.054	0.038
10	0.006	0.004	0.045	0.052	0.012	0.013	0.046	0.034
11	0.005	0.006	0.021	0.021	0.009	0.010	0.039	0.028
12	0.004	0.003	0.023	0.025	0.008	0.007	0.019	0.012
13	0.005	0.003	0.032	0.031	0.007	0.007	0.043	0.045
14	0.004	0.004	0.012	0.015	0.005	0.006	0.035	0.042
15	0.005	0.005	0.016	0.021	0.004	0.007	0.027	0.036
16	0.003	0.003	0.014	0.008	0.004	0.004	0.048	0.029
17	0.003	0.003	0.013	0.015	0.003	0.005	0.017	0.025
18	0.001	0.001	0.009	0.008	0.002	0.001	0.018	0.014
19	0.003	0.002	0.006	0.003	0.002	0.001	0.023	0.011
20	0.046	0.034	0.123	0.084	0.071	0.053	0.194	0.118
21	0.043	0.024	0.083	0.077	0.051	0.024	0.175	0.149
22	0.043	0.035	0.088	0.049	0.051	0.035	0.125	0.201
23	0.027	0.018	0.066	0.060	0.035	0.025	0.257	0.309
24	0.040	0.033	0.065	0.043	0.046	0.030	0.443	0.308
25	0.020	0.022	0.062	0.053	0.026	0.025	0.073	0.0
26	0.043	0.061	0.080	0.070	0.046	0.056	0.786	0.625
27	0.028	0.016	0.084	0.037	0.044	0.017	0.639	0.611
28	0.034	0.016	0.090	0.050	0.037	0.022	1.000	--
29	0.069	0.032	0.084	0.106	0.071	0.039	1.000	1.000
30	0.241	0.317	0.446	0.511	0.338	0.384	1.000	--

Table 3.9

A MEASURE OF FORECASTING ACCURACY UNDER A SIMPLE CONTINUATION ASSUMPTION FOR NAVY ENLISTED PERSONNEL

	Mean Absolute Percentage Error/100					
	Non-ETS		ETS		Both Groups	
Years of Service	1971-80	1976-80	1971-80	1976-80	1971-80	1976-80
1	0.015	0.016	--	--	0.020	0.016
2	0.019	0.017	0.280	0.216	0.036	0.037
3	0.016	0.013	0.187	0.139	0.064	0.044
4	0.014	0.016	0.138	0.097	0.086	0.056
5	0.015	0.005	0.146	0.159	0.037	0.052
6	0.009	0.012	0.060	0.095	0.022	0.018
7	0.005	0.002	0.051	0.077	0.012	0.010
8	0.005	0.003	0.085	0.121	0.019	0.029
9	0.007	0.003	0.069	0.097	0.015	0.014
10	0.005	0.004	0.058	0.058	0.013	0.010
11	0.004	0.002	0.030	0.030	0.005	0.001
12	0.005	0.002	0.029	0.041	0.009	0.006
13	0.004	0.002	0.023	0.022	0.007	0.006
14	0.003	0.002	0.020	0.015	0.005	0.003
15	0.003	0.002	0.008	0.010	0.004	0.004
16	0.004	0.005	0.011	0.008	0.005	0.005
17	0.002	0.001	0.012	0.005	0.002	0.001
18	0.010	0.010	0.017	0.017	0.010	0.010
19	0.061	0.068	0.125	0.113	0.067	0.070
20	0.040	0.037	0.090	0.066	0.049	0.053
21	0.040	0.043	0.089	0.097	0.044	0.052
22	0.035	0.026	0.093	0.112	0.032	0.024
23	0.031	0.033	0.087	0.073	0.035	0.037
24	0.039	0.043	0.084	0.103	0.038	0.043
25	0.025	0.031	0.065	0.069	0.025	0.024
26	0.036	0.022	0.145	0.147	0.047	0.035
27	0.039	0.043	0.105	0.089	0.044	0.046
28	0.037	0.057	0.115	0.120	0.039	0.061
29	0.072	0.052	0.294	0.382	0.095	0.089
30	0.164	0.136	0.341	0.261	0.226	0.187

Table 3.10

A MEASURE OF FORECASTING ACCURACY UNDER A SIMPLE CONTINUATION ASSUMPTION FOR MARINE CORPS ENLISTED PERSONNEL

Years of Service	Mean Absolute Percentage Error/100					
	Non-ETS		ETS		Both Groups	
	1971-80	1976-80	1971-80	1976-80	1971-80	1976-80
1	0.020	0.010	--	--	0.019	0.010
2	0.028	0.017	0.221	0.319	0.072	0.040
3	0.040	0.020	0.215	0.117	0.058	0.057
4	0.055	0.025	0.088	0.105	0.078	0.097
5	0.039	0.024	0.113	0.064	0.034	0.012
6	0.014	0.006	0.097	0.112	0.025	0.024
7	0.018	0.010	0.071	0.103	0.028	0.030
8	0.009	0.006	0.062	0.079	0.032	0.058
9	0.012	0.013	0.064	0.054	0.037	0.031
10	0.011	0.006	0.049	0.077	0.029	0.042
11	0.006	0.004	0.053	0.048	0.014	0.012
12	0.007	0.004	0.032	0.048	0.010	0.013
13	0.008	0.007	0.019	0.019	0.008	0.010
14	0.007	0.006	0.015	0.016	0.008	0.007
15	0.009	0.009	0.022	0.022	0.008	0.010
16	0.007	0.005	0.016	0.014	0.006	0.005
17	0.010	0.007	0.014	0.015	0.009	0.004
18	0.007	0.004	0.015	0.016	0.006	0.003
19	0.026	0.018	0.093	0.100	0.039	0.033
20	0.077	0.065	0.111	0.097	0.099	0.069
21	0.060	0.047	0.130	0.113	0.065	0.029
22	0.046	0.035	0.151	0.108	0.076	0.023
23	0.027	0.011	0.082	0.035	0.054	0.026
24	0.055	0.030	0.085	0.056	0.054	0.045
25	0.043	0.028	0.079	0.083	0.037	0.018
26	0.064	0.029	0.120	0.066	0.077	0.027
27	0.049	0.045	0.171	0.142	0.077	0.086
28	0.069	0.015	0.103	0.095	0.057	0.027
29	0.067	0.044	0.244	0.215	0.093	0.098
30	0.161	0.118	0.330	0.311	0.173	0.279

Table 3.11

A MEASURE OF FORECASTING ACCURACY UNDER A SIMPLE CONTINUATION ASSUMPTION FOR AIR FORCE ENLISTED PERSONNEL

	Mean Absolute Percentage Error/100					
	Non-ETS		ETS		Both Groups	
Years of Service	1971-80	1976-80	1971-80	1976-80	1971-80	1976-80
1	0.016	0.010	--	--	0.016	0.010
2	0.016	0.013	--	--	0.017	0.014
3	0.069	0.037	0.454	0.208	0.068	0.038
4	0.097	0.008	0.285	0.224	0.123	0.126
5	0.017	0.010	0.168	0.075	0.015	0.014
6	0.006	0.004	0.229	0.187	0.035	0.049
7	0.011	0.007	0.192	0.135	0.021	0.017
8	0.022	0.007	0.181	0.124	0.021	0.035
9	0.007	0.007	0.174	0.087	0.008	0.015
10	0.004	0.004	0.143	0.049	0.007	0.011
11	0.004	0.004	0.141	0.051	0.009	0.013
12	0.004	0.002	0.125	0.027	0.006	0.010
13	0.003	0.003	0.128	0.025	0.003	0.004
14	0.002	0.003	0.126	0.018	0.002	0.003
15	0.002	0.002	0.117	0.011	0.001	0.002
16	0.002	0.003	0.114	0.004	0.002	0.003
17	0.002	0.002	0.116	0.007	0.002	0.002
18	0.001	0.001	0.117	0.005	0.001	0.001
19	0.001	0.002	0.124	0.005	0.001	0.001
20	0.065	0.022	0.199	0.106	0.074	0.066
21	0.067	0.055	0.337	0.350	0.070	0.073
22	0.046	0.037	0.352	0.166	0.044	0.060
23	0.041	0.031	0.276	0.244	0.040	0.045
24	0.032	0.027	0.222	0.173	0.044	0.046
25	0.038	0.031	0.204	0.076	0.038	0.036
26	0.041	0.042	0.389	0.248	0.099	0.078
27	0.095	0.091	0.222	0.166	0.109	0.091
28	0.065	0.054	0.440	0.350	0.153	0.105
29	0.076	0.041	0.302	0.147	0.095	0.075
30	0.253	0.185	0.506	0.267	0.693	0.300

THREE- AND FIVE-YEAR FORECASTS

Forecasting errors for three and five years are larger than those for one-year forecasts. If random events were the determining factor, these errors should be approximately the same magnitude. The increases are probably due to the fact that by five years practically all individuals will have had an ETS decision, and nonrandom factors operating at that point in each year cause a widening cumulative error. Average errors for cohorts moving from year of service 1 and 2 generally fall between 12 and 20 percent for 3-year forecasts and between 20 and 30 percent for 5-year forecasts. This means that the size of a cohort moving from year 1 or 2 to year 4 to 5 cannot be estimated--using the simple models--to accuracy greater than 12 to 20 percent or 20 to 30 percent for movement from year 1 or 2 to year 6 or 7. Accuracy improves for later cohorts. For cohorts beginning at YOS 3 or 4, 3-year errors tend to be between 10 and 15 percent, whereas 5-year errors are between 12 and 20 percent. The magnitude of errors decreases until for cohorts starting between years of service 12-14, 3-year errors are usually less than 2 percent, whereas 5-year errors are less than 5 percent. Errors dramatically increase for personnel moving through the reenlistment point of 20 years. Three-year forecast errors are generally less than 15 percent, whereas 5-year errors are usually less than 20 percent. The four services show remarkably similar patterns, with the Marine Corps showing a slightly higher error rate than the other services.

IV. INTEGRATING BEHAVIORAL ESTIMATES INTO LARGE, OPERATIONAL ENLISTED FORCE MODELS

Understanding the accuracy with which projections of enlisted force strength and structure can been made is essential to the design of models that have as their purpose the control of key aggregate manpower parameters such as end strength, accession requirements, first term/career mix, and pay and bonus budgets. A knowledge of this accuracy allows more cost effective hedging of personnel policies and suggests where controls need to be implemented to better manage the enlisted force. More importantly, it can provide directions for improving enlisted force modeling in a way that leads to greater accuracy and more parsimonious models. The latter criterion is an important consideration in model design--especially at the OSD level--where staff size can limit the scope of modeling activities and staff turnover can quickly make complex models extinct.

Manpower models designed for setting enlisted force policy have been of two types. The first type has as their primary purpose the control of aggregate manpower parameters such as end strength, trained strength, accession requirements, direct manpower compensation costs, and enlisted force profiles. These models basically project manpower losses at different experience levels, generate the level and type of manpower gains needed to meet end strengths, and then produce future enlisted force profiles and budgetary costs. The format, approach, and sophistication of these models differ markedly by service.

The second type of modeling has been directed at deriving equations that describe retention or continuation behavior. These models provide measurements of the effect of a variety of variables on enlisted force retention. Variables typically included in such models include military and civilian pay levels, policy variables, unemployment, and demographic characteristics. The models are usually directed at modeling a particular enlistment or reenlistment decision (first term or second term), but models also have been developed which attempt to explain

sequences of retention decisions.[1] These types of models serve two purposes. The first is to define certain key parameters which are used in the policy adjustments of retention rates. These parameters essentially specify how changes in pay and unemployment will affect retention rates. The second purpose is to make forecasts. Forecasts can be made provided the future values of independent variables are known.

The results of these enlistment and retention models as well as results from earlier sections have shown the importance of economic variables in enlistment and retention decisions. Enlistment and retention decisions have been shown to be sensitive to unemployment rates and civilian and military pay levels. It would seem a natural step to incorporate these models into the framework of the larger operating models which need estimates[2] of retention and continuation rates as critical components. This integration would allow simulation of the effects of changes of policy and economic cycles on aggregate manpower trends and development of countercyclical policies to smooth cyclical effects. It should also, in principle, allow more accurate forecasting of retention rates--although this point has not been subject to well documented empirical validation.

Realizing the potential for increased accuracy by integrating behavioral models into manpower systems models means overcoming several

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[1]For an example, see G. A. Gotz and J. J. McCall, *A Dynamic Retention Model for Air Force Officers: Theory and Estimate*, R-3028-AF, The Rand Corporation, December 1984.

[2]Other nonbehavioral techniques for projecting losses have been used or suggested. One technique involves maintaining the basic disaggregation strategy but estimating future continuation rates from a series of past continuation rates. Techniques can include simple averages of past rates, time trends, exponential smoothing, or spectral analysis. Exponential smoothing is a flexible curve-fitting technique where user intervention can set certain constants. Setting these constants can reflect either assessments of the relative weight given to historical data or possible future economic conditions. This subjective intervention makes evaluation of these models difficult, and leaves them highly dependent on the quality of "experts." Spectral analysis techniques are also flexible and are especially suited to fitting cyclical or periodic data which require no user intervention. However, this technique works best when a long series of historical data is available so that cyclical and periodic patterns can be detected. Since current enlisted force data bases contain only 10 years of data, these techniques do not seem currently useful.

barriers which can prevent successful integration and avoiding some pitfalls which could actually decrease accuracy.

One critical problem is that econometric equations are rarely developed for the ideal time periods or precise manpower groups needed by manpower systems models. This mismatch is due fundamentally to differing primary objectives of the two activities. Econometric estimates usually have as their main purpose the measurement of a policy parameter like pay elasticity rather than a time-sensitive forecast. The choice of a data series to make an estimation is often based on some measurement advantage or simple data availability. In the former case, the measurement advantage might include experimental conditions or a large time series or cross-sectional variation in certain variables. Estimation can be a lengthly process, so that available equations cover time periods which lag by a year or two the starting point for needed manpower forecasts.

On the other hand, manpower systems models need econometric equations estimated for specific longitudinal data series specified by the disaggregation scheme of the model. These data series should include the most recent time periods prior to the forecasting periods. Continuously providing these kinds of estimates would considerably expand the scope of present manpower systems models. These models would need an extensive decision support system devoted to storage of longitudinal data. This data base would need to contain not only longitudinal data at the individual level for specific manpower cells, but also extended data series of independent variables. These would include civilian and military pay series, bonus payments, unemployment indicators, and policies affecting retention such as changing benefits. These series could differ between manpower groups so the number of series would proliferate with the number of disaggregated groups. For instance, civilian pay series would differ for males and females, and for different races and education groups.

Since present manpower systems are usually highly disaggregated--often containing thousands of cells--integration of behavioral equations and the associated data support could be a significant investment. This integration also makes the models more complex and somewhat less

responsive, and raises the "price" of disaggregation. For such integrated models parsimony and concern for accuracy should dictate where econometric estimates are used and the basic disaggregation structure of the model. Part of the large-scale disaggregation in present models may be an attempt to compensate for the lack of accuracy inherent when economic parameters are not taken into account. Less disaggregated models incorporating economic variables may be more accurate than highly disaggregate models without them.

Using more sophisticated econometric models and further disaggregation is warranted only where significant gain in accuracy is achievable. Our results in this Note fortunately indicate that high levels of disaggregation may not improve accuracy much, and econometric models may be warranted only for longer term forecasts for ETS groups with between 3 and 10 years of service. Although error rates are high for groups with greater than 20 years of service, the small size of these groups make improved models unnecessary for most policy applications. A more problematical group is the 1-3 YOS group. It is important to predict these groups accurately since they are the largest in the enlisted force. Non-ETS attrition in these groups appears to be more stable than present attrition models based on personnel characteristics would predict. This may indicate that service attrition policies are directed toward creaming any incoming cohort regardless of composition. Thus, traditional methods of disaggregation of these groups by qualitative characteristics may not produce accurate estimates. Instead, qualitative criteria supplemented by upper level bounds on overall attrition levels may produce more accurate estimates.

A second major problem with integrating behavioral models into manpower systems models is the instability of estimations from econometric models. This instability can be caused by dynamic instability in the behavioral phenomena being measured--but is probably more often caused by other factors. These factors include the lack of a unique theoretically determined model, different measures of variables, different estimation techniques, and use of different time periods in the estimations. Estimation is still somewhat of an art loosely constrained by theory. Thus, it is important to have a uniform, well-regulated process for comparing forecasts and for documenting

assumptions, model specifications, and estimation procedures. It is important to distinguish between differences in models and differences in forecasts. Differences in models or estimations might frequently produce little differences in forecasts.

A third problem with incorporation is the need to predict future values of independent variables in the econometric models. The models contain variables that are outside DoD policy control and for which future values may be highly uncertain. The accuracy of forecasts is thereby dependent not only on the "quality" of model specifications and the statistical characteristics of the model estimations, but also on uncertainity in assigning values to future parameters.

Another complication is that the functional forms used to fit econometric equations may not be compatible with those needed in manpower systems models. Nonlinear logit functions are often used to fit the dichotomous retention or attrition behavior. The logit estimates give the probability of attrition or retention for individuals with differing characteristics under different choices of policy parameters (military pay) and other factors (unemployment). This functional form is chosen primarily because of its asymptotic behavior which limits the probability value to between zero and one. The problem arises when these individual level estimates are used to predict the retention or attrition behavior of a heterogenous group of enlisted personnel. The accepted method for deriving the retention rate of a group is to calculate the logit probability for each individual and sum these probabilities over the group. In manpower systems models this procedure requires an unmanageably large individual level data base and redesign of the models using microsimulation. Instead, simple linear fits using estimates from the logit fits are usually developed that can be varied continuously within certain limits of the independent variables.

A second reason is that nonlinear functions can complicate these larger optimization models which attempt to choose values or policy variables contained in the continuation rate. Large-scale linear optimization models can easily adapt to linear functions. However, retention rates cannot be estimated with linear functions since values of the dependent variable must be kept between zero and one.

Incorporating nonlinear function means additional computational work to develop piecewise linear functions or change to a nonlinear programming environment. In the latter case, the "size" of the problem is much more restrictive than with linear programming.

A final reason for lack of integration is that the magnitude of differences in forecasting accuracy between the simple continuation models and more sophisticated models has not been estimated. The difference between the two types of models may not be sufficient to justify the resources necessary for incorporating the more complex models. Unfortunately, forecasts are not routinely made by those building econometric retention models. Given that forecasts occur, a tracking system to measure the historical accuracy of various models is critical to the process of model validation and improvement. This process is perhaps the key missing ingredient in improving enlisted force forecasting.

Tracking the accuracy with which enlisted manpower levels can be forecast is useful not only in designing improved forecasting levels, but the expected uncertainty in forecasts is itself a key policy planning parameter. Determining the likely accuracy of forecasts allows managers to properly hedge their actions to meet requirements with prescribed levels of confidence. It is often more important to assume with a high degree of confidence that manpower of certain types will exceed a certain level than to simply be able to predict the expected value of a level. The amount of hedging required will depend partly on the level of uncertainity--more uncertainity means more hedging. Hedging is accomplished through planning for a level of manpower above requirements. Several other parameters determine the increment over requirements necessary for hedging--the level of confidence, the perceived cost of shortages, the cost of the additional manpower, and the number of personnel in the inventory.

Taking account of uncertainity in planning the levels of enlisted manpower inventories of various types is essential to effective management of the enlisted force. These factors make enlisted force planning not a simple quantitative exercise in forecasting from existing historical data, but a coordinated organizational effort to make explicit and estimate (sometimes subjectively) the uncertainty in forecasts, costs of shortages, and required levels of confidence.

V. CONCLUSIONS

This study of the accuracy of enlisted strength forecasting in the four services for fiscal years 1971 through 1980 shows that simple continuation rate models have severe limitations when projecting over three or five years. Forecasting errors arise because of large errors encountered in forecasting for ETS groups that tend to be cumulative. These ETS errors are largest for personnel at first and second term and between 20 and 30 YOS. Breaking enlisted groups into finely disaggregated subgroups improves forecasting only a little. The major component contributing to error appears to be a nonrandom component occurring at the point of ETS that is correlated across enlisted groups by YOS. Failure to incorporate these nonrandom components severely limits the accuracy of enlisted force forecasting. These nonrandom components are being systematically incorporated into the enlisted force models of the four services. Many analytical and practical problems remain to valid integration. Thus, forecasting accuracy of these models may be limited and need systematic tracking.

These nonrandom components are attributable to variations associated with the economic cycle. Econometric estimates made over a number of years have shown the sensitivity of ETS decisions to economic variables. Moreover, the pattern of errors found in this study is consistent with the hypothesis that missing economic variables are the main contributers to the error rates for three- and five-year forecasts. Making enlisted forecasting more accurate means finding ways of incorporating these variables into the enlisted models of the services.

This incorporation of economic variables into the large-scale enlisted force models of the services should be one goal of enlisted force management. Perhaps the major problem in enlisted force management in the next five years will be developing countercyclical policies during a period of improving economy. This kind of planning will be impossible unless the services themselves can generate these estimates. Moreover, OSD should not duplicate the capability that exists within the services for enlisted force modeling. Rather, OSD

should be in a position to exert influence on the direction of modeling activities within the services through its review and understanding of model assumptions, and to coordinate, where appropriate, modeling assumptions across services. Three critical components in performing these functions are the ability to test and track the accuracy of enlisted manpower projections, a process for coordinating and establishing common assumptions across services, and revised Department of Defense Instructions that emphasize model assumptions in addition to model outputs.

Testing the accuracy of enlisted models requires developing a certain type of enlisted force model at the OSD level that can be used to check the output of service models against some standard model assumptions. Such models should emphasize flexibility and decision support capability rather than comprehensiveness or even technical sophistication or complexity.

There are several barriers to incorporating behavioral estimates into the large-scale models. The high degree of disaggregation used in most models means making a large number of behavioral estimates. This study, however, indicates that a high degree of disaggregation may not contribute greatly to improving accuracy. In fact, less disaggregated models incorporating economic variables may provide far greater accuracy than highly disaggregated models without economic variables.

This study has also shown that behavioral estimates may only be needed for certain key groups. Simple continuation models often provide surprisingly good estimates. Another barrier is development of estimates that are based on the behavioral history of the group being forecast. Although several econometric estimates have been made on differing groups at different times, ad hoc extractions of parameters from these models and incorporation into other models are dangerous. Rather, resources need to be devoted to maintaining a fairly large support system of longitudinal data so that estimates can be generated for key groups rather easily. The problem will still remain that econometric estimates are not highly reliable or repeatable across similar groups at different times. So part of the estimation capability must be ways of statistically testing the effect of different parameters on the overall quality of fit.

Yet another barrier is that behavioral models themselves need estimates of future economic parameters. These estimates have not been highly reliable in the past. Thus, it is important to have a mechanism for establishing consistent estimates of these parameters across services and a means to test sensitivities to variations from forecasts. Another barrier concerns the specification and linking of functional forms for the behavioral models. Current logit functional forms--often used in behavioral estimates of discrete choice--may provide poor quality of fits over certain portions of the curve. These poor fits could interfere with the goal of providing overall improved accuracy. More research is needed to develop better fitting forms. Finally, incorporating these more complex functional forms into enlisted force models may be simple in certain types of models, but more complex in optimization models which have traditionally relied on linear estimates. However, none of these barriers is of sufficient complexity to deter movement forward. Indeed, the results of this study seem to indicate a marked improvement in enlisted forecasting accuracy may be possible with models that are estimated from continuous longitudinal data for the group in question--but that incorporate fairly simple economic variables.

Appendix A
THE DATA BASE

The data base was constructed by matching (by Social Security number) beginning fiscal year master file records for each service with ending fiscal year records. Flags were then attached to the data records to indicate either a match or a nonmatch. Master file records were next extracted and saved for each beginning year record--where a match existed--for a end year record. An extract of this tape with the data elements of Table A.1 was then made.

Table A.1

DATA ELEMENTS INCLUDED ON TAPE EXTRACT

Position	Description
1	Social Security Number
3	DoD Primary Occupation Code
4	DoD Duty Occupation Code
6	AFQT Percentile Score
7	Pay Grade
8	Home of Record
9	Date of Birth
10	Service
11	Race
12	Source of Original Procurement
13	Duty in Vietnam
14	Marital Status
15	Number of Dependents
17	Ethnic Group
19	Sex
21	Education Group
23	Mental Category
24	Age at Entry
26	Primary MOS
31	ETS Date
32	Date of Current Pay Grade
34	Service Component
35	TAFMS Group
38E	Variable/Selective Reenlistment Bonus Multiplier
39E	Proficiency Pay
40E	Reenlistment Eligibility
45	Spanish Surname Flag

Appendix B
COMPARISON OF ERRORS WITH BINOMIAL ERRORS FOR FOUR SERVICES

Table B.1

Z STATISTICS FOR ARMY ENLISTED PERSONNEL

YOS	1971	1972	1973	1974	1975	1976	1977	1978	1979	Number Significant at 10%	5%	1%
1	156.26	-3.27	-21.34	0.40	3.15	27.11	1.65	-5.02	-6.53	8	7	7
2	170.76	101.56	1.45	44.40	62.89	52.55	-5.76	6.92	-13.13	8	8	8
3	58.60	-3.70	34.45	8.06	-9.00	21.37	7.27	15.79	39.29	9	9	9
4	25.82	20.93	19.92	-10.25	-22.43	5.29	-32.95	-0.85	24.75	8	8	8
5	4.02	6.54	16.36	-1.24	-1.75	2.14	8.75	-5.23	7.35	8	7	6
6	2.08	3.76	7.75	3.93	-7.44	-6.18	5.02	-1.92	2.31	9	8	6
7	-0.06	1.36	5.37	-0.01	-6.40	-5.97	-9.97	6.72	7.32	6	6	6
8	-4.31	1.13	4.08	-5.96	-4.33	5.01	-6.10	6.69	8.77	8	8	8
9	-3.78	-0.36	2.03	-4.14	-3.53	7.98	2.58	0.02	0.80	6	6	5
10	-6.04	-0.61	0.86	-2.15	-5.51	4.69	2.62	-2.10	3.57	7	7	5
11	-0.81	-2.75	1.09	-3.25	-1.78	4.23	3.19	-2.16	1.07	6	5	4
12	-4.63	0.48	0.72	-3.23	-1.26	3.53	1.18	0.26	2.41	4	4	3
13	-3.75	-1.06	0.59	-4.32	-1.12	3.04	-1.12	0.75	2.82	4	4	4
14	-0.97	0.71	-1.30	-1.57	-1.42	3.58	0.82	-1.19	2.20	2	2	1
15	-0.78	-0.13	-0.24	0.57	-0.56	1.91	1.56	-2.60	3.35	3	2	2
16	-2.49	0.39	2.10	-2.87	0.56	3.18	0.74	-1.43	1.20	4	4	2
17	-0.77	1.73	-0.23	-0.98	-1.27	3.88	1.98	-2.88	0.60	4	3	2
18	1.64	0.67	1.27	0.21	0.24	2.20	0.15	0.10	-0.81	2	1	0
19	-0.80	4.19	0.50	-0.34	1.82	1.71	-0.12	-0.01	0.31	3	1	1
20	-1.27	-7.88	7.56	-6.45	6.19	8.60	-0.39	1.98	5.74	7	7	6
21	-1.99	0.81	5.53	-7.04	8.52	-1.54	0.30	-1.87	3.07	6	5	4
22	4.93	-1.16	3.12	-4.23	6.77	1.00	2.77	-2.32	3.07	7	7	6
23	-0.17	-0.50	4.39	-2.48	5.23	-1.14	-2.32	-0.38	1.85	5	4	2
24	1.17	-1.87	4.56	-1.00	5.83	0.45	-2.59	-0.78	2.37	5	4	3
25	0.72	0.96	2.18	1.07	2.25	1.02	3.40	-0.21	1.06	3	3	1
26	-2.43	0.10	2.23	0.66	1.91	2.90	-1.93	-1.56	2.91	6	4	2
27	0.68	-1.49	4.25	-0.81	2.34	0.20	-0.25	0.07	1.70	3	2	1
28	0.69	-0.08	4.47	-0.28	2.08	0.03	-0.05	-1.01	1.64	2	2	1
29	-1.08	2.00	1.06	-3.07	4.11	-0.67	1.31	-0.24	1.55	3	3	2
30	0.46	-4.40	-1.28	-3.41	0.52	0.12	-1.17	1.95	-2.64	4	3	3
Significant at												
10%	16	13	18	17	22	21	17	15	21			
5%	15	11	18	17	18	19	15	12	19			
1%	11	10	14	15	15	17	13	8	15			

Table B.2

Z STATISTICS FOR NAVY ENLISTED PERSONNEL

YOS	1971	1972	1973	1974	1975	1976	1977	1978	1979	Number Significant at 10%	5%	1%
1	-2.30	-6.57	-20.02	23.40	-1.61	16.87	7.09	6.10	-3.22	8	8	7
2	-1.86	37.72	-2.65	14.59	6.28	49.04	3.28	7.56	-12.81	9	8	8
3	6.01	-5.78	-49.47	-25.25	33.64	39.38	-9.78	7.43	-9.15	9	9	9
4	-3.76	29.88	24.86	11.13	5.24	8.56	-1.48	-11.71	13.88	8	8	8
5	1.98	-5.65	11.89	11.44	-0.20	-7.27	-19.77	-10.03	12.42	8	8	7
6	-8.82	-4.42	4.21	-0.41	1.58	-2.44	3.91	-3.15	-3.41	7	7	6
7	0.16	-2.07	3.88	6.21	-3.53	-2.46	-5.05	2.73	0.48	7	7	5
8	1.88	1.85	0.58	-1.77	-4.79	-12.66	0.63	2.99	5.59	7	4	4
9	3.54	-1.15	-0.12	2.11	-9.68	-3.19	-0.13	3.15	4.81	6	6	5
10	1.85	-3.51	2.70	1.36	-7.24	-0.80	-2.90	0.98	2.91	6	5	5
11	1.03	-4.33	-0.35	1.71	-2.97	-0.06	-0.84	-0.04	0.48	3	2	2
12	3.67	-4.59	-2.77	3.55	-3.21	-3.62	1.32	-0.75	-0.10	6	6	6
13	4.51	-2.60	-2.14	0.79	-3.40	1.27	-0.93	-0.87	3.83	5	5	4
14	3.55	-2.31	1.69	-1.00	-4.58	-0.50	0.02	-1.09	1.42	4	3	2
15	3.14	-2.74	-1.02	0.90	-1.78	-0.33	-1.35	1.72	-2.31	5	3	2
16	1.54	-4.33	-2.53	3.40	-0.14	-0.05	-2.74	1.80	2.01	6	5	3
17	-0.10	-3.22	-2.70	-0.55	2.03	0.57	0.29	-0.35	0.23	3	3	2
18	-2.40	-7.46	-3.24	-0.85	3.62	3.45	7.94	2.16	-0.14	7	7	5
19	8.41	-11.20	-3.31	-3.06	5.71	5.36	23.89	-0.48	7.11	8	8	8
20	3.09	-1.96	0.22	2.76	5.78	1.29	-1.28	-5.46	5.79	6	5	5
21	1.31	-0.11	-3.25	1.93	3.35	0.92	-4.45	3.82	3.22	6	5	5
22	2.29	-2.16	-1.27	-0.56	1.55	0.76	-1.25	0.42	2.73	3	3	1
23	0.89	0.69	-3.12	0.53	1.25	-1.21	-1.73	1.10	3.25	3	2	2
24	2.44	-1.49	1.23	-1.32	-0.15	0.24	-1.13	-1.56	5.15	2	2	1
25	1.49	-1.87	-0.93	0.89	0.29	-1.68	-0.02	-0.64	1.92	3	0	0
26	3.97	-2.94	-0.69	-0.21	1.56	-2.29	0.01	0.47	1.73	4	3	2
27	2.57	-0.81	-0.42	0.76	-1.97	0.34	0.98	-1.03	2.79	3	3	1
28	0.81	-0.88	-1.86	-0.17	-0.61	2.46	-1.05	-1.31	2.88	3	2	1
29	1.41	-0.46	-3.84	-3.29	3.79	-0.09	0.93	-2.49	3.38	5	5	4
30	4.44	-1.38	-0.80	-3.47	1.12	1.45	-0.32	1.39	2.10	3	3	2
Significant at												
10%	21	22	19	16	19	15	12	15	24			
5%	18	19	17	13	18	14	11	13	22			
1%	12	16	15	12	16	10	11	11	19			

Table 8.3

Z STATISTICS FOR MARINE CORPS ENLISTED PERSONNEL

YOS	1971	1972	1973	1974	1975	1976	1977	1978	1979	Number Significant at 10%	5%	1%
1	9.60	1.71	-2.56	-10.26	20.41	-0.36	0.54	12.10	-1.91	7	5	4
2	25.74	-4.83	30.04	0.21	40.08	30.21	8.87	5.84	-9.76	8	8	8
3	0.34	17.86	3.08	-6.31	20.23	9.29	-20.93	14.80	-0.96	7	7	7
4	1.95	13.81	4.26	-0.05	-2.83	-3.10	-7.85	12.05	9.17	8	7	7
5	4.60	15.69	1.39	2.10	-0.75	-1.41	-0.11	-0.80	-3.12	4	4	3
6	2.20	5.92	0.92	0.10	-2.64	0.41	-1.79	5.10	3.80	6	5	4
7	2.94	5.42	-0.31	0.56	-1.96	-3.63	-2.08	5.90	0.01	6	5	4
8	2.17	-0.84	0.12	1.64	0.10	-7.85	-2.90	7.21	3.09	6	5	4
9	-5.87	1.86	-3.22	2.29	-1.29	-0.91	-0.25	8.34	1.55	6	4	3
10	-2.12	1.39	0.95	-0.23	0.56	-2.08	4.24	5.06	3.13	5	5	3
11	-0.55	2.76	-0.49	-1.24	0.81	-0.34	0.56	2.51	2.01	3	3	1
12	-1.51	-0.38	0.52	-0.77	0.55	-0.25	1.97	-1.52	1.32	1	1	0
13	-1.33	-0.60	1.02	0.24	-0.05	-0.47	1.67	-0.25	1.98	2	1	0
14	0.37	-0.73	1.54	-0.67	1.35	-0.49	1.48	-0.89	0.33	0	0	0
15	-0.15	1.44	0.04	-0.75	2.16	-1.12	1.10	1.14	1.58	1	1	0
16	2.43	0.52	0.22	-0.31	1.30	0.19	0.42	0.99	1.27	1	1	0
17	2.74	-0.09	2.33	-1.93	2.30	0.38	1.06	0.0	1.61	4	3	1
18	2.00	3.11	-0.45	-0.36	1.53	0.22	0.35	0.76	1.29	2	2	1
19	-8.89	3.58	2.22	-1.09	1.35	2.26	9.73	-0.76	0.91	5	5	3
20	-4.09	-0.68	5.55	-4.46	3.26	2.97	-0.70	-0.56	4.76	6	6	6
21	0.17	1.16	2.46	-4.59	4.87	-0.42	-0.71	-0.35	1.98	4	4	2
22	-0.25	3.16	1.63	-5.83	4.38	-0.01	0.37	-0.80	1.37	3	3	3
23	1.94	1.45	0.71	-2.39	2.53	-1.38	0.07	-0.05	1.24	3	2	0
24	2.69	0.48	0.69	-1.42	1.84	-0.87	-0.93	1.99	0.71	3	2	1
25	0.32	2.91	0.42	-1.48	1.35	-0.02	-0.50	1.02	-0.40	1	1	1
26	-3.11	4.04	-0.29	-1.39	1.41	0.15	0.19	-0.75	0.95	2	2	2
27	2.62	-0.06	0.20	-0.78	2.03	-1.12	1.39	-1.73	1.65	4	2	1
28	0.57	-0.85	0.92	-1.23	1.87	0.08	0.40	0.66	-0.62	1	0	0
29	1.13	0.17	-2.08	-0.49	1.32	2.58	-1.41	0.73	0.85	2	2	0
30	-0.83	-0.62	0.08	-0.31	-0.05	-0.79	0.58	2.06	1.16	1	1	0
Significant at												
10%	18	14	10	10	15	9	10	13	13			
5%	16	12	10	8	12	9	8	12	10			
1%	11	12	5	5	8	6	6	9	7			

Table B.4

Z STATISTICS FOR AIR FORCE ENLISTED PERSONNEL

YOS	1971	1972	1973	1974	1975	1976	1977	1978	1979	Number Significant at 10%	5%	1%
1	5.38	-24.54	-2.93	11.08	9.30	1.05	6.30	-4.29	7.77	8	8	8
2	-12.35	-24.20	-7.45	7.25	-0.85	14.71	1.04	6.39	3.91	7	7	7
3	9.31	-76.11	60.80	-19.63	-6.14	28.13	12.89	20.38	3.34	9	9	9
4	9.78	7.93	37.11	-2.34	36.87	22.62	-40.55	-4.62	12.94	9	9	8
5	5.35	1.29	-2.22	-3.71	-10.97	4.06	-9.14	-0.68	2.00	7	7	5
6	-7.06	-5.67	-5.67	-7.82	12.37	-3.16	-31.04	-5.53	8.64	9	9	9
7	-16.21	-2.56	0.43	-5.89	4.74	-1.36	9.18	0.40	7.88	6	6	5
8	3.17	1.85	2.47	0.84	1.76	-8.10	4.46	-6.67	11.10	8	6	5
9	0.57	-1.19	0.44	-0.63	-1.47	0.18	-9.97	-4.50	-2.00	3	3	2
10	-2.02	-2.32	0.71	-0.59	-3.57	-4.64	-5.34	1.16	-3.57	6	6	4
11	0.62	-3.53	0.40	-1.45	-3.65	-1.69	-7.85	-0.06	6.78	5	4	4
12	1.16	-2.44	0.37	0.24	-0.48	-1.19	-6.33	1.88	3.91	4	3	2
13	0.58	-0.93	-0.13	0.96	-1.31	-1.55	-2.43	-1.35	2.66	2	2	1
14	0.91	-1.63	0.99	0.91	-1.62	-2.44	-1.49	-0.19	1.30	1	1	0
15	-0.39	-1.50	0.40	0.11	-0.56	-2.54	-0.29	-0.55	-0.96	1	1	0
16	0.55	-1.76	1.12	0.15	-0.30	-1.70	-3.03	2.12	1.44	4	2	1
17	-0.71	-0.51	0.14	2.35	-3.52	-1.05	-0.80	2.84	-1.88	4	3	2
18	1.54	1.07	-0.51	0.31	-0.33	-1.85	1.49	0.99	-1.25	1	0	0
19	1.18	1.10	-1.11	-0.20	1.02	-0.46	0.47	2.46	-2.17	2	2	0
20	-14.09	10.43	5.39	6.02	3.52	5.36	-3.71	4.02	10.08	9	9	9
21	-14.39	9.15	-2.05	5.47	-5.73	7.03	-8.89	1.60	6.54	8	8	7
22	-6.84	1.49	1.55	1.55	-3.07	5.04	-6.27	-1.04	7.30	5	5	5
23	-7.04	-0.73	-5.92	-0.16	-0.02	0.36	-2.22	1.35	8.01	4	4	3
24	-5.30	-1.40	4.83	4.52	0.62	-1.82	-5.63	0.44	6.86	6	5	5
25	-7.30	2.46	1.36	3.00	2.95	-2.29	-4.68	-0.10	5.63	7	7	5
26	-8.23	-5.08	-7.13	-0.96	2.38	-0.25	-2.08	4.18	6.71	7	7	5
27	-8.51	-1.58	-2.28	7.19	-2.58	4.16	-4.55	-0.08	5.12	7	7	5
28	-9.06	-6.07	-3.79	1.28	3.58	1.24	-2.32	-0.22	6.59	6	6	5
29	-4.29	0.27	-3.72	-0.99	4.13	-1.82	0.86	-0.15	4.45	5	4	4
30	-4.90	-2.34	-9.68	-1.97	2.64	1.41	0.97	2.53	3.43	7	7	4
Significant at												
10%	20	17	16	14	19	19	22	14	26			
5%	20	15	16	14	18	14	22	13	25			
1%	19	10	12	11	16	11	18	10	22			

END

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